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PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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VOLUME 58 **JULY 1955** NUMBER 691

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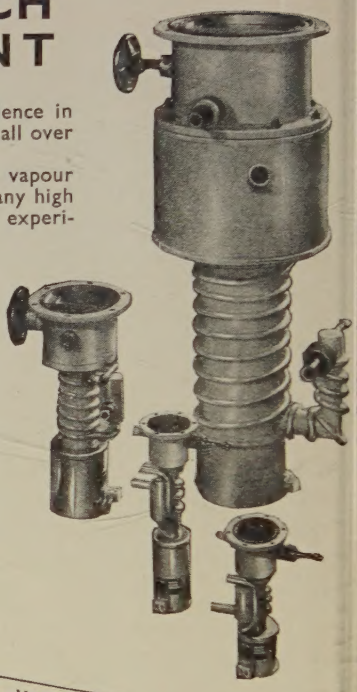

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*F203	60–70	50	3	2
403	300–350	170–200	3	4
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Amplifiers
Electroacoustic apparatus
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953) and the Supplements published with the Indexes to Volumes 56 (1953) and 57 (1954). Reprints of the List of Journals (1953) and the Supplements (1953 and 1954) can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Amer. math. Monthly	*American Mathematical Monthly.* [Abstracted by *Mathematical Reviews.*]
Atti Sem. Mat. Fis. Univ. Modena	*Atti del Seminario Matematico e Fisico dell'Università di Modena.* [Abstracted by *Mathematical Reviews.*]
Bull. Earthquake Res. Inst. [*Tokyo*]	*Bulletin of the Earthquake Research Institute, Tokyo.* [Abstracted by *Mathematical Reviews.*]
J. appl. Physiol.	*Journal of Applied Physiology.* 2101 Constitution Avenue, Washington 25, D.C.
Math. Scand.	*Mathematica Scandinavica.* [Abstracted by *Mathematical Reviews.*]
Rev. Mexicana Elect.	*Revista Mexicana de Electricidad.* Apartado Postal 9238, Mexico D.F., Mexico.
Rozpravy Česko Akad. Véd Ser. TV	*Rozpravy Československé Akademie Véd, Řada TV.* Nalkadatelství Československé Akademie Véd, Václavské nám. 34, Prague II.
Svetotekhnika	*Svetotekhnika.* Mezhdunarodnaja Kniga, Moscow.
Univ. Roma Ist. Naz. Alta Mat. Rend. Mat. e Appl.	*Università di Roma. Istituto Nazionale di Alta Matematica. Rendiconti di Matematica e delle sua Applicazione.* [Abstracted by *Mathematical Reviews.*]

New Journal

J. Inst. Telecomm. Engrs [*New Delhi*]	*Journal of the Institution of Telecommunication Engineers.* Post Box 841, New Delhi. Quarterly. Volume 1, Number 1 dated *March*, 1955. Annual subscription: Rs. 15/–. Price Rs. 5/– per copy.

Note

The publications of the Professional Groups of the Institute of Radio Engineers are now listed as *Institute of Radio Engineers Transactions* [*I.R.E. Trans*] instead of *Transactions of the Institute of Radio Engineers Professional Group* [*Trans Inst. Radio Engrs Prof. Group*] in conformity with the title now in process of adoption.

Errata

Abstr. 3383 (1955) line 5: *for* to decimal places *read* to 10 decimal places.

Abstr. 3385 (1955) Table 2: *for* 0(·1)10 *read* 0(·01)10.

Table 4: *insert* 9*D at end.*

MATHEMATICS 51

512.3

5161. A short table of the Laguerre polynomials. L. J. SLATER. *Proc. Instn Elect. Engrs, Monogr. No.* 136, publ. *June*, 1955, 5 *pp.* [To be republished in **102 C** (1955).]

A table of the function $L_n(x)$ referred to in Abstr. 10723 (1954), over the range $n = 0(1{\cdot}0)10{\cdot}0$, $x = 0(0{\cdot}1)5{\cdot}0$, correct to six places of decimals.

517.9

5162. A method for the numerical integration of differential equations of second order without explicit first derivatives. R. DE VOGELAERE. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 3, 119–25 (*March*, 1955).

This is a fourth-order step-by-step method based on difference formulae. The case of a single equation is discussed in detail. The application of this method to automatic computers is considered. A.

518.2

5163. Tables of the functions $D_0(x)$ and $D_1(x)$. H. GELLMAN AND J. TUCKER. *Atomic Energy Canada Rep. No.* 99, 51 *pp.* (*Feb.*, 1954).

The function of

$$x,\ D_0(x) = (1/\pi)\int_{-\pi/2}^{\pi/2} d\theta \exp(-x\cos\theta),$$

and the negative of its first derivative, $D_1(x) = -D_0'(x)$, are tabluated for $x = 0(0{\cdot}001)4{\cdot}999$ to 7 decimal places. A.

ASTRONOMY . ASTROPHYSICS . GEODESY 52

522.613

5164. A thallium-lamp photometer for the coronal observation. M. NOTSUKI, S. NAGASAWA AND I. SHIMIZU. *Ann. Tokyo Astron. Obs. Univ. Tokyo*, **3**, *No.* 4, 182–5 (1953).

A photometer, attached to a direct-vision spectroscope, employs an artificial-slit image illuminated by the 5 350 Å emission from an Osram thallium lamp as the comparison field whose brightness is controlled by a sliding wedge-filter. D. R. BARBER

523.11

5165. On a cosmogonical hypothesis. Q. MAJORANA. *R.C. Accad. Naz. Lincei*, **17**, *No.* 5, 150–7 (*Nov.*, 1954) In Italian.

The author's theory of gravitation involves the absorption by matter of gravitational flux and it is assumed that this process would result in the generation of heat, the heat developed in a massive body being proportional to the square of the mass. The astrophysical consequences of this hypothesis are discussed with special reference to the surface temperatures of planets. [See also Abstr. 4450 (1949).] R. A. NEWING

523.11

5166. Newtonian cosmology. W. H. MCCREA. Letter in *Nature* [*London*] **175**, 466 (*March* 12, 1955).

In reply to recent criticisms, it is shown that the Milne–McCrea cosmology is self-consistent when correctly formulated for an arbitrarily large system, but difficulties arise for an unbounded system. R. A. NEWING

523.11 : 523.875

5167. The luminosity function and stellar evolution. E. E. SALPETER. *Astrophys. J.*, **121**, *No.* 1, 161–7 (*Jan.*, 1955).

The evolutionary significance of the observed luminosity function for main-sequence stars in the solar neighbourhood is discussed. The hypothesis is made that stars move off the main sequence after burning about 10% of their hydrogen mass and that stars have been created at a uniform rate in the solar neighbourhood for the last five billion years. Using this hypothesis and the observed luminosity function, the rate of star creation as a function of stellar mass is calculated. The total number and mass of stars which have moved off the main sequence is found to be comparable with the total number of white dwarfs and with the total mass of all fainter main-sequence stars, respectively. A.

523.112

5168. The steady-state theory of the homogeneous expanding universe. F. A. E. PIRANI. *Observatory*, **74**, 172–3 (*Aug.*, 1954).

Whitrow's paradox [Abstr. 1964 (1954)] would arise only if a distant object C disappeared from the region visible to an observer A, but this would not happen if A is assumed to have idealized instruments. A careful analysis is made of the terms "observable region" and "horizon," and it is shown that difficulties have arisen from different usages. Whitrow's "observable region" is made up of events which, at a given epoch, are or have been visible to A, and this region is of infinite extent. Hoyle's "observable region" consists of events in A's present which are or will become visible to A, and is a region whose finite extent is defined by the reciprocal of Hubble's constant. The present note clarifies the earlier discussion of Bondi, Gold and Whitrow [*Observatory*, **74**, 36–8 (*Feb.*, 1954)]. R. A. NEWING

523.112

5169. The "horizon" of the steady-state universe. T. GOLD. Letter in *Nature* [*London*] **175**, 382–3 (*Feb.* 26, 1955).

In a review [*Nature* [*London*] **175**, 68–9 (*Jan.* 8, 1955)] of essays on the age of the universe published in the *British Journal of Philosophical Science* (*Nov.*, 1954), attention was drawn to obscurities concerning

the size of the observable universe in steady-state cosmology (see also preceding abstract). The present note restates certain aspects of the theory. With given observing apparatus the range of observation is finite and constant, but could be extended with improved sensitivity. There is no theoretical limit to the time of reception of signals from another galaxy, but there is a limit to the time of emission of a signal to be transmitted to a specified galaxy. Gold's letter is followed by comments by the writer of the original review. R. A. NEWING

523.161

5170. Interstellar polarization by graphite particles. R. CAYREL AND E. SCHATZMAN. *Ann. Astrophys.*, **17**, *No.* 6, 555–74 (1954) In French.

It is suggested that the observed interstellar polarization of starlight may be caused by scattering from graphite (carbon black) particles which may form in the convective clouds at the boundary between H I and H II regions. Laboratory tests with colloidal suspensions of graphite are described which lend support for the above mechanism. D. R. BARBER

523.161

5171. Acceleration of interstellar clouds by *O*-type stars. J. H. OORT AND L. SPITZER, JR. *Astrophys. J.*, **121**, *No.* 1, 6–23 (*Jan.*, 1955).

A possible mechanism is proposed for the acceleration of interstellar clouds. The ultraviolet light from a newly born *O* star heats the gas in a dense interstellar cloud from 100 to 10000°K. The resultant increase in pressure leads to high accelerations, and in this way an appreciable fraction of the radiant energy from a hot star may be converted into kinetic energy of cloud motions. Since a detailed treatment of this problem would be very intricate, involving an integration through time both of the hydrodynamic equations and of the equation of radiative transfer, a preliminary analysis is carried through. When the side of the cloud facing the *O* star is heated, the heated cloud gases expand into the less dense material between the cloud and the *O* star. The momentum carried away by these gases is computed approximately, on the assumption that the pressure of the gas originally surrounding the cloud is negligible. The acceleration of the cloud is then found from the momentum carried away, with the use of Newton's third law of motion but with complete neglect of all detailed hydrodynamic effects within the cloud. The analysis is applied to three physical situations: (*a*) formation of an *O* star near a single dense cloud, which then becomes accelerated; (*b*) approach of a cloud to an *O* star in a steady state, with repulsion of the cloud by the "rocket effect" of the expelled gases; (*c*) formation of an *O* star in an extended cloud complex of such large mass that the *O* star can ionize only part of it; the outside cool shell may then be driven away. In all three cases, the mass of the neutral cloud decreases during the interaction with the radiation field, and very high velocities may be attained. It seems possible to explain by such mechanisms the high velocities that are observed in the faint components of interstellar lines. It may be, even, that all random cloud motions in the interstellar gas originate in this way. A.

523.164

5172. A solution for the path of radio waves through the solar atmosphere by elliptic integrals. T. HATANAKA. *Ann. Tokyo Astron. Obs. Univ. Tokyo*, **3**, *No.* 4, 234–45 (1953).

It is shown that, with the assumptions of (i) a spherically-symmetrical corona, (ii) absence of magnetic fields, (iii) electron density distribution of the form $N = a'z^{-6} + b'z^{-4} + c'z^{-2}$, where z is the radial distance of a point on the ray, the angle θ (which is the angle measured at the centre of the sun between the direction of a typical point on the ray and the direction of a point on the ray when $z = \infty$) can be expressed in terms of elliptic integrals. The theory is applied (*a*) to calculate the directivity of a noise storm emitted isotropically with random polarization (absorption being neglected) and (*b*) to trace the refraction of the rays of a radio star when occulted by the solar corona. Theoretical expressions for the absorption of radiowaves in the corona are also given, but no applications of the formulae are made.

M. W. OVENDEN

523.164

5173. Discrete sources of extra-terrestrial radio-frequency radiation. *U.R.S.I. Special Rep., No.* 3, 56 *pp.* (1954).

Report of a sub-committee of U.R.S.I. A brief historical survey of observations of discrete radio sources is followed by discussions of (i) the identification of individual sources with optically-observed objects, (ii) preliminary attempts at setting up a radio magnitude scale and its comparison with optical magnitudes for extragalactic systems, and the spectrum indices of various sources, (iii) the distribution of the sources in galactic longitude and latitude, (iv) ionospheric scintillation and refraction, and (v) methods of detecting the sources and measuring their positions and angular sizes. The report is intended to be a survey of papers published up to 1952, although more recent work is referred to in footnotes.

M. W. OVENDEN

523.164

5174. A catalogue of reliably known discrete sources of cosmic radio waves. J. L. PAWSEY. *Astrophys. J.*, **121**, *No.* 1, 1–5 (*Jan.*, 1955).

As a part of the work of Commission 40 of the International Astronomical Union, a list of reliably known discrete sources of cosmic radio waves has been prepared by a committee consisting of J. G. Bolton, R. Hanbury Brown, F. G. Smith, and B. Y. Mills. In this paper this list is published, with a short description of the catalogue by the president of the commission, J. L. Pawsey. A.

523.164

5175. Distribution of radio brightness across the Andromeda nebula. J. D. KRAUS. *Nature* [*London*] **175**, 502–3 (*March* 19, 1955).

The observations of M31 were made on 250 Mc/s with a 96-helix aerial of dimensions 160 ft E–W, 22 ft N–S, aperture area 3520 ft, giving an aerial pattern for a point source which is 1°·3 between half-power points in R.A. and 8° in Dec. A one-dimensional brightness distribution is obtained by averaging a number of different runs, and subtracting the profile

of the galactic background. The radio profile is compared with published photographic isophotes, and with a photographic brightness profile that would be observed with an optical system having the same response pattern as the aerial used. The asymmetry observed optically is also found on the radio wavelength, but the extension of the nebula is considerably greater for the radio observations, the nebula extending 6° south-preceding and 3° north-following, corresponding to an overall diameter of 256 000 light years on the new distance scale. The ratio of radio to photographic brightness is much higher for the outer regions than for the nebula as a whole. The total intensity of the nebula was found to be $\sim 10^{-24}$ $W.m^{-2}(c/s)^{-1}$. Fine-structure at the limit of resolution is indicated. M. W. OVENDEN

523.164 : 621.396.677

5176. A new aerial system for radioastronomical observation of the brightness of the sun on 9 350 Mc/s. J. ARSAC. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 9, 942–5 (*Feb.* 28, 1955) In French.

The multiple-beam interferometer with similar aerials equally spaced along a line gives the higher-order harmonics of the one-dimensional brightness distribution across the sun with much smaller relative amplitudes than those of the low-order harmonics. It is shown that, with a system of four similar aerials spaced along a line at distances of 0, *a*, 4*a*, 6*a* from a fixed reference point, although the side-lobes are large, the same harmonics are observed as would be observed with a uniformly-spaced 7-element interferometer, but each harmonic is observed with its true amplitude. In the actual system used, $a = 58\lambda$, the total length of the grating is 348λ (= 11·20 m), each element is a paraboloidal aerial of diameter 1·10 m, and the width of the sensitivity pattern is 6 ft between half-power points. M. W. OVENDEN

523.5

5177. The physical theory of meteors. VI. The light-curve. A. F. COOK. *Astrophys. J.*, **120,** *No.* 3, 572–7 (*Nov.*, 1954).

For Pt V, see Abstr. 6227 (1954). The conventional theory for predicting the light-curve of a meteor is applied to a bright meteor photographed with the Super-Schmidt cameras of the Harvard Meteor Expedition and is shown to be inadequate over the faint early portion of the trail, the meteor being fainter than predicted. An improved theory, based on the reaction-zone model and including thermal radiation from the body, provides a completely satisfactory fit to the observed light-curve. A.

523.5

5178. The physical theory of meteors. VII. On meteor luminosity and ionization. F. L. WHIPPLE. *Astrophys. J.*, **121,** *No.* 1, 241–9 (*Jan.*, 1955).

The relative frequencies of occurrence of radio and bright photographic meteors suggest either (*a*) that the ratio of meteoric ionization to luminosity varies as (velocity)^2 or (*b*) that there exists a surprising dependence of particle size upon orbital characteristics. The writer prefers the first alternative, which leads to about a (velocity)^5 law for the ionizing efficiency per gram. An order-of-magnitude deficiency in radio meteors at velocities above 60 km/sec may well arise from a suppression of radio-velocity measures for faint meteors above an altitude of about 110 km by rapid diffusion of the ion column. Meteor ionization, like a persistent meteor train, probably also decays extremely rapidly below about 82 km. The combined effects of rapid electron diffusion at high altitude and decay at low altitudes would reduce the slope of the mean height-velocity curve for radio meteors as compared to photographic meteors. In this manner, conflicting data concerning the efficiencies of ionization versus luminosity for meteors may be reconciled. A.

523.5

5179. The physical theory of meteors. VIII. Fragmentation as cause of the faint-meteor anomaly. L. G. JACCHIA. *Astrophys. J.*, **121,** *No.* 2, 521–7 (*March*, 1955).

The observed decelerations and light-curves of bright meteors are in good agreement with the simple ballistic theory, while fainter meteors photographed with the Super-Schmidt cameras in New Mexico show startling anomalies. In particular, the durations of faint meteors are shorter and the decelerations increase faster than predicted by the theory, when the mass is computed from the integration of the luminous-intensity-curve, in the same fashion as for bright meteors. Extreme fragility and progressive fragmentation seem to account for these and other anomalies. The concept of pellet-like meteors must be replaced with that of a cluster of breaking fragments in the case of most smaller bodies. A.

523.5 : 538.566.2

5180. Forward-scattering of radio waves by meteor trails. P. A. FORSYTH AND E. L. VOGAN. *Canad. J. Phys.*, **33,** *No.* 5, 176–88 (*May*, 1955).

Radiowaves which are too high in frequency to be reflected by the ionospheric layers are often reflected back to the earth's surface by the ionization in meteor trails, and may be detected at distances of the order of 1 000 kilometres from the transmitting station. These forward scattered signals have been studied by the use of several transmission paths in Canada. The paper summarizes the characteristics of the individual signals and presents some preliminary results of the investigation. It seems likely that the technique will prove to be useful in meteoric studies. A.

523.741

5181. The solar photospheric gradient. S. W. HENRIKSEN. *Astrophys. J.*, **120,** *No.* 3, 521–8 (*Nov.*, 1954).

From microdensitometer measurements on solar-spectrum photographs of the 1945 eclipse, a value of $-7{\cdot}6\times10^{-8} \pm 0{\cdot}6\times10^{-8}\,cm^{-1}$ was derived for the photospheric gradient, a value which corresponds to 4 400°c for the region measured. A.

523.741

5182. Additional data for turbulence spectrum of solar photosphere at long wave lengths. F. N. FRENKIEL AND M. SCHWARZSCHILD. *Astrophys. J.*, **121,** *No.* 1, 216–23 (*Jan.*, 1955).

A plate showing the granulation with exceptional definition was selected from the regular Mount Wilson solar programme. On this plate 8 000 intensity measurements were made. The measurements

were analysed in terms of a turbulence spectrum of photospheric intensities. The spectrum, when corrected for the finite resolution of the photograph, is found to be fairly constant in the wavelength band from 2000 to 30000 km. This result for the turbulence spectrum of photospheric intensities is similar to the earlier indications found for the turbulence spectrum of velocities, in showing that the spectrum contains much energy in the wavelength band around 15000 km, but disagrees with them in not showing in the corrected spectrum a large decrease from 15000 to 4000 km. A.

523.745

5183. A statistical analysis of spectroheliograms. J. B. ROGERSON, JR. *Astrophys. J.*, **121,** *No.* 1, 204–15 (*Jan.*, 1955).

The intensity fluctuations appearing on hydrogen and calcium spectroheliograms of the quiet sun have been analysed to obtain a distribution of the scale lengths of the fluctuations. The Mount Wilson spectroheliograms used were taken in the centre of the Hα line and the centre of the *K* line. Two sizes of spectroheliogram image were analysed. The intensity was measured at equidistant points along straight lines across the image. Mean lagged products were then computed from these intensities. The smallness of their probable errors indicates that the amount of data used (5820 points in each wavelength) is sufficient to provide statistically stable results. The Fourier transform of the mean-lagged-product function gave the power spectrum of the intensity variations along straight lines. Assuming the fluctuations to be two-dimensionally isotropic it is possible to derive a two-dimensional spectrum from the one-dimensional spectrum. The two-dimensional spectra thus obtained suggest that for Hα the intensity fluctuations have scale lengths principally in the range 5000–30000 km, while for *K* the scale lengths are much longer and are largely confined to the range 25000–70000 km. A.

523.746

5184. Intensity variation in sunspots. W. A. MILLER. Letter in *Nature* [*London*] **175,** 557–8 (*March* 26, 1955).

Three runs of 8 exposures, each run being of duration 1 sec, are published from a cinematograph record of the development of the penumbra of a sunspot. The recorded spectral range was between ~3000 and ~5700 Å. The development of the penumbra is accompanied by a brightening of that part of the penumbra adjacent to the umbra. Apparent tangential speeds ~50000 km/sec are observed for the bright region, suggesting an excitation mechanism rather than actual motion of material.

M. W. OVENDEN

523.746 : 550.385

5185. Geomagnetic activity and sunspots. P. SIMON. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 9, 940–2 (*Feb.* 28, 1955) In French.

Sunspots are classified as type R if they give rise to enhanced radio radiation, and as type Q if they do not. Sunspots are also classified by their flare activity by two criteria: (*a*) the occurrence of major flares of intensity 3 or 3+, and (*b*) the frequency of flares in general. Statistically, spots of class R are associated with an enhancement of geomagnetic activity during central meridian passage, while spots of class Q are associated with a diminution of geomagnetic activity. The geomagnetic effects do not appear to depend statistically upon the flare activity given by either criterion (*a*) or criterion (*b*). M. W. OVENDEN

523.746 : 550.385

5186. Chromospheric flares of particular importance and geomagnetic activity. P. SIMON. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 10, 1056–8 (*March* 7, 1955) In French.

See preceding abstract. The geomagnetic activity over a period of a few days about the day of occurrence of a solar flare of importance 3 or 3+ is examined statistically. For spots of class R, an enhancement of geomagnetic activity is observed, while for class Q spots a diminution is observed in 75% of cases. The effect for class Q spots may be the statistical effect of geomagnetic activity associated with the central meridian passage of such spots, unrelated to flare activity. For class R spots, the data are divided into two groups: central flares within 45° of the centre of the disk, and non-central flares outside this limit. The enhancement of geomagnetic activity is statistically similar for both groups. It is suggested that there are two distinct geomagnetic effects: the first, highly directional, is associated with the central meridian passage of spots of type R, and the second, much less directional, with the occurrence of major flares in class R spots. M. W. OVENDEN

523.752

5187. The solar chromosphere. E. BÖHM-VITENSE. *Z. Astrophys.*, **36,** *No.* 2, 145–80 (1955) In German.

This empirical determination of the structure of pressure and temperature in the chromosphere, using Cillié's and Menzel's measurements of 1935, shows that the density decreases in medium and greater heights, with an equivalent height of about 1000 km. The radiation temperatures of the metals are about 4000°; the ionization temperatures are by about 1000° higher. Diagrams and tables illustrate the results in considerable detail, leading to a discussion of the consequences of this new chromospheric model and to a satisfactory comparison with the observations.

A. BEER

523.752

5188. The prominence of July 25, 1951. K. ROTHSCHILD, J.-C. PECKER AND W. O. ROBERTS. *Astrophys. J.*, **121,** *No.* 1, 224–30 (*Jan.*, 1955).

The motions of 49 knots in the large prominence of July 25, 1951, have been measured. For 17 of them, a definite variation of acceleration vectors has been found. The dynamics of the motion still remains obscure. It seems difficult to represent them by a coherent field of forces. Moreover, gravity seems to play no rôle in this prominence. A.

523.755

5189. Electron densities in the outer solar corona on February 25, 1952. R. MICHARD. *Ann. Astrophys.*, **17,** *No.* 6, 429–42 (*Nov.–Dec.*, 1954) In French.

Electron densities have been determined for distances from 1·5 to 10 solar radii, using photometric and polarimetric observations of the French and Italian (Arcetri) eclipse-expeditions. The author assumes that the whole of the observed polarization

is due to electron scattering, and that the *F*-corona is unpolarized. The equatorial corona outside the great streamers, the polar corona, and the large streamer at the east-limb are treated separately. The resulting electron densities are considerably higher than those of van de Hulst's model, particularly for the polar zones. The ratio of the mean electron density within this streamer (and in its neighbourhood) to that of the normal equatorial corona increases rapidly with increasing distance from the sun, up to about 3·5 radii, and then remains constant for greater distances. Further results, discussed in detail, indicate a kind of discontinuity at about 3·5 radii.

A. BEER

523.76

5190. The abundance of metals, structure of densities, and collision damping in the solar atmosphere. V. WEIDEMANN. *Z. Astrophys.*, **36**, *No.* 2, 101–44 (1955) In German.

Calculated on the basis of Böhm's model of the radiation equilibrium, the abundances for iron follow now to about $\frac{1}{4}$, and those of the other metals to about $\frac{1}{2}$ of the values given by Claas in 1951. The ratio hydrogen/metals is now about 20000 : 1, and, consequently, the new electron pressure comes out smaller and the gas pressure higher. With the newly determined structure of the pressure, theory and observation are then compared for the wings of the strong Fraunhofer lines, in order to test the theory of damping. The results derived for the systems with one electron agree with the van der Waals theory, while for the more complex spectra the observed damping exceeds the theoretically expected values, e.g. for chromium and iron about five times. A newly developed mathematical procedure is outlined. A. BEER

523.76 : 523.877

5191. On toroidal magnetic fields in the sun and stars. C. PLUMPTON AND V. C. A. FERRARO. *Astrophys. J.*, **121**, *No.* 1, 168–74 (*Jan.*, 1955).

Torsional oscillations of a liquid sphere of infinite electrical conductivity in the presence of a permanent axi-symmetric magnetic field are considered. It is shown that axially symmetric oscillations can be excited in which the sphere oscillates in shells generated by the rotation of the lines of force about the axis of symmetry. The range of frequencies forms a continuous spectrum, but this degeneracy may be due to the approximations made and may disappear when a rotating sphere is considered. The bearing of this solution on problems of interest in solar magnetism is also discussed. A.

523.775

5192. Identification of the yellow coronal line. C. PECKER, D. E. BILLINGS AND W. O. ROBERTS. *Astrophys. J.*, **120**, *No.* 3, 509–20 (*Nov.*, 1954).

Confirmation of Edlén's tentative identification of Ca XV as the atom responsible for the yellow coronal emission line λ5694 is given. From line-profile analysis, the atomic weight of the responsible atom is shown to be close to 40. The existence of an additional emission line at about λ5446, demanded by theory and previously reported by Waldmeier, is verified. The ratio of the intensities λ5694/λ5446 is found to be in agreement with theoretical values for Ca XV emission. A.

523.775

5193. Coronal line intensities at the Khartoum eclipse. R. G. ATHAY AND W. O. ROBERTS. *Astrophys. J.*, **121**, *No.* 1, 231–40 (*Jan.*, 1955).

Coronal line and continuum intensities were measured at several position angles on the limb and as a function of height above the limb on the slitless spectrograms obtained at Khartoum by the High Altitude Observatory. The lines $\lambda\lambda$5303, 6374 and 7892 and the continuum were measured at fifteen points around the limb. The relative line and continuum intensities around the limb showed large variations. In one active region where the emission in some lines was intense, the yellow coronal line λ5694 was observed. In this same region the lines λ6702 and λ7060 were intense enough to measure, and it was found that lines of high ionization potential were at maxima in intensities, whereas lines of low ionization potential were at minima. The yellow line was at maximum in this region, confirming that it is a high-ionization-potential line. The correlation between line and continuum intensities was found to increase markedly as the ionization potential increased for the three lines studied. The correlation between line intensities was found to increase as the difference in ionization potential decreased. Intensities of λ5303, λ7892, and the continuum were measured as a function of height above the limb in four regions. Two of these regions were active centres, one of which showed the yellow line, and two were more nearly average regions. The change of λ7892 intensities with height in the latter two regions showed that the maximum intensity occurred below 10000 km. Changes in the relative intensities of the two lines with height showed that in the yellow-line region the temperature decreased with height, but in the other regions the temperature increased with height. A comparison of the changes in line intensities to the changes in continuum intensities showed that the average temperature in the active regions was above the value at which the line λ5303 had a maximum intensity, but in the two more normal regions the temperature was between the limits where the lines λ5303 and λ7892 have maxima. The active regions were found to be regions of high density. A.

523.855

5194. On the inapplicability of the theory of fluctuations to galaxies. J. NEYMAN AND E. L. SCOTT. *Astron. J.*, **60**, *No.* 2, 33–8 (*March*, 1955).

With reference to the theory of fluctuations, it is shown that the formula representing the expected value of the square of the number of images of galaxies, counted in a region ω on the photographic plate, is of the wrong order of magnitude. As a result, another formula, representing the correlation between counts of images of galaxies in two equal regions ω_1 and ω_2, appears to be independent of the size of the regions. In actual fact, the true value of the correlation must decrease to zero as $\omega_1 = \omega_2 = \omega \to 0$. This fact is confirmed by the empirical values of the correlations based on Shane and Wirtanen's counts of galaxies. As a consequence, the constants

of the fluctuation theory, obtained by fitting the serial correlations, based on a formula independent of ω, to empirical values corresponding to any fixed ω, say $1° \times 1°$, do not reflect the properties of the distribution of galaxies in space but reflect the fortuitous circumstance that the empirical data refer to $1° \times 1°$ squares rather than to $10' \times 10'$ squares or $5' \times 5'$ squares. A.

523.872 : 519.2

5195. On the solution of an integral equation of astrophysical and statistical interest. S. S. HUANG. *Ann. Astrophys.*, **18,** *No.* 1, 42–64 (1955).

The equation is $g(x) = \int \phi(y) f(x-y) dy$. A variational method is first investigated, but the greater part of the paper is devoted to the special case when $f(x)$ is given by a Gaussian function. A.

523.877

5196. Note on the possibility of polytropic stars with power law for opacity and subatomic energy generation. G. BANDYOPADHYAY. *Bull. Calcutta Math. Soc.*, **46,** *No.* 2, 135–8 (*June*, 1954).

A mathematical discussion based on equations for the stellar opacity, κ, and the rate, ε, of subatomic energy generation for a particular star, having the form, $\kappa = K \cdot Q^a T^v$ and $\varepsilon = C \cdot Q^b T^w$, where K and C are constants depending on the stellar material. Three cases are considered, of which two are shown to be physically untenable. It is concluded that any star with a uniform rate of energy production throughout its mass can be a polytrope. D. R. BARBER

523.877

5197. Radiative equilibrium in a hydrogen atmosphere. I. A. F. COOK. *Astrophys. J.*, **120,** *No.* 3, 578–88 (*Nov.*, 1954).

The optical properties of neutral hydrogen atoms are discussed, the Gaunt factors being taken into account. Absorption cross-sections per atom in the second quantum level at the short-wavelength side of the Balmer limit are evaluated. The ratio of the absorption cross-section at a specific wavelength to that at the short-wavelength side of the Balmer limit is tabulated for a number of wavelengths and temperatures. The Rosseland mean opacity coefficient is calculated, and an integral occurring in the equation of radiative equilibrium is tabulated. A.

523.877

5198. On the dynamical stability of magnetic stars. G. R. BURBIDGE. *Astrophys. J.*, **120,** *No.* 3, 589–95 (*Nov.*, 1954).

The condition for dynamical stability in a star having a decaying magnetic field has been investigated for two models: (*a*) a stellar model computed by Schwarzschild which has a given conductivity distribution, and (*b*) the uniform sphere. The magnetic energies and the critical fields for instability have been tabulated. A.

523.877

5199. The electromagnetic field of an idealized star in rigid rotation *in vacuo*. A. J. DEUTSCH. *Ann. Astrophys.*, **18,** *No.* 1, 1–10 (1955).

A magnetic star is idealized as a perfectly conducting, sharply bounded sphere, rigidly rotating *in vacuo*. It is then proved that the field equations are satisfied by magnetic fields of arbitrary geometry, including fields symmetrical about an axis inclined to the rotational axis. For a particular case of such a model, the boundary conditions are satisfied at the surface of the star, and the external field is found. This has the property that near the star the electric vector has a component along the magnetic vector. At sufficiently low densities of the circumstellar medium, this field would accelerate ions to very high energies. It is improbable that near a real star the density can be low enough for such acceleration processes to occur. A.

523.877

5200. On the density and temperature dependence of the free-free hydrogen transition probabilities. M. RUDKJØBING. *Ann. Astrophys.*, **18,** *No.* 1, 11–24 (1955).

The Gaunt factor for absorption by free-free transitions in hydrogen is calculated in the limit of long wavelengths as a function of density and temperature in a one-electron, dipole-radiation approximation. The factor is found to be a function of the combination $T\rho^{-2/3}$ of the physical parameters and its value ranges from 0·4 for the sun to 1·6 for *Y Cyg*. A.

523.877

5201. The radial oscillations of stellar models with high mass concentration. P. LEDOUX, R. SIMON AND J. BIERLAIRE. *Ann. Astrophys.*, **18,** *No.* 1, 65–75 (1955) In French.

The radial oscillations of two models with high central condensation but with low values of the effective polytropic index in the external layers are studied. It is found that the periods of the fundamental mode extend over an interesting range covering the periods of cepheids of type I and partially at least those of type II. An approximate formula for the period of the fundamental mode is given which might prove useful for the whole range of central condensations. A.

523.877

5202. The transfer of radiation by an emitting atmosphere. IV. C. A. LUNDQUIST AND H. G. HORAK. *Astrophys. J.*, **121,** *No.* 1, 175–82 (*Jan.*, 1955).

For Pt III, see Abstr. 8881 (1954). The problem of the radiation intensities for a plane-parallel atmosphere containing a distribution of emission sources given by an arbitrary polynomial of the optical depth is solved for isotropic scattering. Both finite and semi-infinite atmospheres are considered. The quadratic case is considered in detail as an example. A.

523.877

5203. The transfer of radiation by an emitting atmosphere. V. C. A. LUNDQUIST. *Astrophys. J.*, **121,** *No.* 1, 183–9 (*Jan.*, 1955).

Finite and semi-infinite plane-parallel atmospheres with source functions for emission sources of the form $\varepsilon(\mu) = \mu^n$ and $\varepsilon(\tau, \mu) = \mu^n \tau^m$, with m and n being positive integers, are considered for isotropic scattering. The emergent intensities are found for the case of the first source function, and a similar method is indicated for the second case. A.

523.877

5204. Calculation of the adiabatic coefficient of compressibility for a gaseous mixture. M. HÉNON. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 9, 947–9 (*Feb.* 28, 1955) In French.

A formula is derived when allowance is made for radiation pressure and for variations in the ionization of H, other elements being completely ionized.

R. A. NEWING

523.877 : 521.042

5205. Origin of anomalous abundances of the elements in giant stars. A. G. W. CAMERON. *Astrophys. J.*, **121,** *No.* 1, 144–60 (*Jan.*, 1955).

Following the exhaustion of hydrogen in the cores of certain massive stars, it appears that the cores contract and the envelopes expand, the stars becoming red giants. When the central temperature and density have increased sufficiently, thermonuclear reactions involving the helium in the core can take place with the nuclei which have taken part in the carbon cycle. The rate of the $C^{13}(\alpha,n)O^{16}$ reaction is calculated; it is found to produce neutrons rapidly at a temperature of 10^8 °K and a density of 5×10^4 g/cm^3. These neutrons are slowed down until they reach thermal equilibrium with their surroundings (neutron energies of about 10 keV) and are then captured by the surrounding nuclei in proportion to their cosmic abundances and neutron-capture cross-sections. The latter quantities are estimated for neutron energies of 10 keV as a function of the mass number of the capturing nucleus. The heavier nuclei each appear to capture many neutrons (about 35 neutrons at mass number 100). Nuclei with closed shells of 50, 82 and 126 neutrons have much smaller cross-sections and become concentrated by the neutron-capture processes. With the assumption of a moderate amount of mixing between core and envelope of the star, it is thus found that the distinctive features of *S*-type and Ba II-type spectra can be explained. The further evolution of the star should then lead to the production of excess carbon by the Salpeter reactions, and the spectrum should gradually turn into that of type *R* or *N*. A.

526.75

5206. A determination of the differences in gravity between the National Physical Laboratory, Teddington, the Dominion Observatory, Ottawa, and the National Bureau of Standards, Washington. G. D. GARLAND AND A. H. COOK. *Proc. Roy. Soc. A*, **229,** 445–58 (*May* 24, 1955).

529.786 : 621.3.018.4 : 621.317.76

5207. The quartz clock as frequency and time standard. A. SCHEIBE. *Elektrotech. Z.* [*ETZ*] *A*, **76,** *No.* 4, 153–8 (*Feb.* 11, 1955) In German.

Reviews the development of the various forms of standard quartz crystal clocks in England, U.S.A. and Germany. The different shapes of crystal used and their respective *Q*'s are compared. The latest (1954) PTB (German) clock has a *Q* of $\sim5\times10^6$. The merits of the Pierce–Miller (parallel resonance), Meacham (series resonance) and the Pierce (crystal between anode and grid) arrangements are compared. The Pierce arrangement is used in the latest PTB clock. Comparison data are tabulated and there are 25 refs.

S. WEINTROUB

PHYSICS 53

53.081 : 621.3.081

5208. On the universal system of units. G. P. ABRAMOVICH. *Radioteknika*, **10,** *No.* 1, 72–3 (1955) In Russian.

The recent proposal by I. G. Klyatzkin [*Ibid.*, **9,** No. 1 (1954)] to introduce a "universal" system of units is criticized. This was claimed to have advantages over the c.g.s. system and to avoid the defects of the m.k.s. system. The usual charges made against the former regarding the "smallness" of its units are shown to be unsupported since the application of electromagnetism requires a vast range of magnitudes anyway. It is stated that the principal defect of the u.s. is its artificiality. For example the intensities of the magnetic and electric fields are measured in the same units, volts/metre. This is deplored as unprogressive. S. C. DUNN

53.081 : 621.3.081

5209. On the universal system of units. I. G. KLYATSKIN. *Radiotekhnika*, **10,** *No.* 1, 74–7 (1955) In Russian.

The author's previous proposal [*Ibid.*, **9,** *No.* 1 (1954)] having been misinterpreted (preceding abstract) is explained in more detail. In Maxwell's equations a dimensioned constant k_0 is introduced such that div $D = k_0\rho$. This relieves the burden of having to ascribe dimensioned properties to free space such as is necessary in the m.k.s. system. Since the effect of inserting a piece of dielectric into a field is only to alter the magnitude of the field by polarization effects, the medium constant should be dimensionless. The confusion which does exist is traced to the use of mechanical analogies in explaining field action. In the u.s. the characteristic impedance of free space is unity, *E* and *H* have the same dimensions and it is shown that the units are conveniently adapted for tensor representation. S. C. DUNN

FUNDAMENTALS 530.1

530.12

5210. On a new theory of "definitive relativity." L. FANTAPPIÈ. *R.C. Accad. Naz. Lincei*, **17,** *No.* 5, 158–65 (*Nov.*, 1954) In Italian.

Space-time is assumed to admit a 10-parameter group of motions and therefore to be of constant curvature *C*. The associated group Fn^{10} is taken to define the structure of physical theories. The Lorentz group is the limit of this group as $C\to0$, but it is shown that Fn^{10} cannot itself be regarded as the limit of another 10-parameter group and is therefore regarded as the final or definitive group of physics. R. A. NEWING

530.12

5211. The pole-dipole particle in a gravitational and electromagnetic field. A. PAPAPETROU AND W. URICH. *Z. Naturforsch.*, **10a,** *No.* 2, 109–17 (*Feb.*, 1955) In German.

Relativistic equations of motion for a spinning particle are derived and the Lagrange and Hamiltonian formulations are discussed. The general form of the theory is presented as a simple extension of known results for the gravitation-free case, e.g. in the presence of the two fields, the momenta $p_i \rightarrow p_i - e\Phi_i - \Gamma^{\lambda}_{i\nu} v^{\nu} s_{\lambda}$. Classical Poission bracket expressions are constructed with properties analogous to those of the Dirac matrices. R. A. NEWING

530.12

5212. The field of a uniformly accelerated charge, with special reference to the problem of gravitational acceleration. H. BONDI AND T. GOLD. *Proc. Roy. Soc. A*, **229,** 416–24 (*May* 10, 1955).

Physically significant limiting processes are employed to derive the correct field of a uniformly accelerated charge. This solution is used to discuss a difficulty associated with the field of a charge statically supported against gravity. A.

530.145 : 539.11 : 539.152.1

5213. Topics from the conference of physicists at Spała [Poland] held on 1–14 September, 1952. [Materiały z Konferencji fizykow w Spałe.] Chief editor: L. INFELD. *Warsaw: Panstwowe Wydawnictwo Naukowe* (1954) 366 *pp.* In Polish.

This is a report of the third in a series of annual physics conferences and consists of the papers listed below and discussions transcribed from tape recorders. Russia was represented by W. Fock, Bielov and R. Chentsov, whose impromptu report on the state of research on superfluids in the U.S.S.R. is included. Original work reported here is mainly published elsewhere also (usually in *Acta Physica Polonica*).

Part I. Fundamental problems. *On the development of the concept of matter in physics*, L. Infeld and L. Sosnowski. *Criticism of the Copenhagen School according to Blokhintsev*, Z. Kopeć. *Criticism of Bohr's view of quantum mechanics*, W. Fock. *The work of D. Bohm on the interpretation of quantum theory with the aid of hidden parameters*, J. Plebański. *On Fényes' interpretation of quantum mechanics*, R. Ingarden.

Part II. Nuclear physics. *Present state of the theory of nuclear forces*, J. Werle. *The influence of non-static terms on nuclear potentials*, J. Werle. *Collisions and nuclear forces*, R. Kołodziejski. *Current work at the H. H. Wills Physical Laboratory in Bristol*, M. Danysz. *Nuclear paramagnetic resonance*, A. Hrynkiewicz. *Bloch's theory of nuclear paramagnetic resonance*, M. Suffczyński. *New model-hypothesis of the nucleus*, J. Pniewski. *Electric nuclear quadrupole moments*, H. Niewodniczański. *Chemical binding, the polarization of particles and the scattering of neutrons*, J. Janik.

Part III. Solid state physics. *Current problems in the physics of semiconductors*, L. Sosnowski. *Certain problems in the electron theory of the solid state*, B. Buras. *On problems of transistors in semiconductors*, Z. Kopeć. *Present state of the theory of "F-centres,"* W. Ścisłowski. *Researches of Soviet physicists in the field of superfluids*, R. Chentsov. *Theory of ferroelectrics of the type of $BaTiO_3$*, A. Piekara.

Part IV. Field theory. *On the latest developments of classical electrodynamics*, L. Infeld. *A supplement to L. Infeld's lecture on electrodynamics without potentials*, J. Plebański. *The Hamiltonian in electrodynamics formulated without potentials*, M. Suffczyński. *Hamiltonian formulation of non-linear electrodynamics*, M. Suffczyński. *The elementary law [of interaction] and non-linear electrodynamics*, J. Plebański. *The question of the motion of bodies in Einstein's theory of gravitation*, W. Fock. *New results in quantum field theory*, J. Rayski. *The question of an elementary length in physics*, J. Weyssenhoff. *Five-dimensional field theories (with special reference to Rumer's theory)*, R. Ingarden. W. J. SWIATECKI

530.145

5214. Construction of propagators by the method of quasi-fields. YU. A. GOL'FAND. *Zh. éksper. teor. Fiz.*, **28,** *No.* 2, 140–50 (1955) In Russian.

The quasi-fields are defined such that the vacuum expectation values of their products give the Feynman functions, i.e. $\langle \bar{\psi}_{\alpha\rho}(x)\psi_{\beta\sigma}(y)\rangle_0 = \frac{1}{2}\delta_{\rho\sigma}S^F(y-x)$ $\langle \phi_r(x)\phi_s(y)\rangle_0 = \frac{1}{2}\delta_{rs}D^F(x_2-y)$ where ψ ahd ϕ are the operators of the nucleon and meson quasi-fields respectively. Rules for constructing propagators are given which are shown to give results equivalent with those of the ordinary theory. The propagators are given in the form of infinite-dimensional integrals. G. E. BROWN

530.145

5215. Singular integral equations in quantum field theory. J. C. TAYLOR. *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 4, 679–87 (*April*, 1955).

The covariant theory of meson-nucleon scattering contains a vertex-part equation which is a singular integral equation. Because of this, there is a difficulty about the treatment of a renormalization constant. It is shown here how a consistent use of a high-energy cut-off overcomes this difficulty. A related difficulty for the Bethe–Salpeter equation cannot be overcome by the same method. A.

530.145

5216. Dirac bracket transformations in phase space. P. G. BERGMANN AND I. GOLDBERG. *Phys. Rev.*, **98,** *No.* 2, 531–8 (*April* 15, 1955).

The purpose of this paper is twofold. One is to analyse the group-theoretical significance of the Dirac bracket and to examine, in particular, the apparent ambiguities in the presence of both first-class and second-class constraints. The other is to prepare the ground for the utilization of the Dirac bracket for the quantization of generally covariant theories. It is shown that the Dirac bracket represents the commutator of infinitesimal transformations in phase space which are not canonical but form a group, in that they are the only transformations that preserve the form of all the constraints of a theory as well as the canonical form of the equations of motion. This group of transformations possesses an invariant subgroup: those transformations that correspond to co-ordinate transformations, gauge transformations and the like.

From this subgroup the factor group can be reconstructed. All members of the original group have generators, but the generators of the invariant subgroup are zero. There is, then, a one-to-one correspondence between the non-vanishing generators and the members of the factor group. The Dirac bracket is uniquely defined for all dynamical variables that can serve as generators; excluded are variables that have no invariant significance (such as the divergence of the electromagnetic vector potential). If it is possible to identify all these permissible generators, then the theory can be reformulated in terms of these and will be free of constraints. It is proposed to adopt the set of generators and the Dirac brackets between them as the point of departure for the formulation of covariant quantum theories. A.

530.145

5217. Existence of Dirac generating functions. P. G. BERGMANN. Letter in *Phys. Rev.*, **98,** *No.* 2, 544–5 (*April* 15, 1955).

In a recent paper (preceding abstract) it was shown that the generators permissible in a Dirac bracket must satisfy a certain condition. The question now discussed is whether this condition is self-consistent.

L. S. GODDARD

530.145

5218. A simple derivation of Klein–Nishina formula without matrices. K. C. KAR, S. SANATANI AND R. K. BHATTACHARYYA. *Indian J. theor. Phys.*, **2,** *No.* 2, 49–68 (*Sept.*, 1954).

The Klein–Nishina formula for differential cross-section of Compton scattering, so far deduced only on the basis of Dirac's theory of the electron, is derived here by an alternative method which does not involve Dirac's non-commutative matrices. The lengthy and intricate "spur" calculation has been avoided and it is shown how the exact formula can be obtained by the ordinary process of summation. On using the linear form of the relativistic Hamiltonian recently obtained by Kar and Sanatani [Abstr. 5296 (1954)] the differential cross-section has been calculated by the usual methods. The general formula thus derived involves a number of undetermined $\pm$ signs, which are to be so adjusted that the general formula may reduce to the Thomson formula obtained by applying the general perturbation theory to low-energy interaction. This method, however, does not completely remove the uncertainty of $\pm$ signs and two alternative formulae are obtained both of which reduce to the Thomson formula for low energy of the incident radiation ($k_0 \ll \mu$). Of these one is found to be untenable as it fails to explain large-angle scattering at high energy. The other is the exact Klein–Nishina formula. A.

530.145

5219. Relativistic Hamiltonian and wave equations of an electron in an assembly. S. SANATANI. *Indian J. theor. Phys.*, **2,** *No.* 2, 79–86 (*Sept.*, 1954).

The method of linearizing the relativistic Hamiltonian of an electron in an assembly without the use of matrices, previously given by Kar and Sanatani [Abstr. 5296 (1954)], is further discussed here. Linear wave equations have been obtained from the linear Hamiltonian, and it has been shown that even if the spin-orbit interaction energy E_{so} is not included in the Hamiltonian, the correct second-order wave equation and the fine structure formula follow automatically. A.

530.145

5220. On the quantum theory of non-local interactions. G. WATAGHIN. *R.C. Accad. Naz. Lincei*, **17,** *No.* 5, 166–7 (*Nov.*, 1954) In Italian.

Continuation of previous work [Abstr. 5272 (1954)]. Formulates rules for construction of the general term in the S-matrix using a specific form-factor.

J. M. RADCLIFFE

530.145

5221. Glauber approximation for scattering. K. M. GATHA AND A. L. MATHUR. Letter in *Curr. Sci.*, **24,** *No.* 2, 43–4 (*Feb.*, 1955).

Points out similarity between Glauber approximation (1953) for small-angle scattering at high energies, and the classical approximation. N. M. KING

530.145

5222. Singular potentials in relativistic equations of motion. J. WERLE. *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 4, 537–42 (*April*, 1955).

It is shown that in relativistic equations of motion for a particle moving in external potentials some additional forces of purely relativistic origin appear. These forces are repulsive for scalar and pseudoscalar potentials thus preventing the particle from coming too near to the singularity of the potential in spite of its apparently attractive character. An adiabatic approximation to the interaction potential for two nucleons interacting through the pseudoscalar field is obtained. An interesting feature of this potential is a strong repulsive term acting at short distances between nucleons. A.

530.145

5223. The construction of potentials from the S-matrix for systems of differential equations. R. G. NEWTON AND R. JOST. *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 4, 590–622 (*April*, 1955).

The procedure for constructing all potentials belonging to a given S-matrix and prescribed eigenvalue is generalized to systems of equations of the type of the Schrödinger equation for S-states. The determination of the spectral function from the S-matrix is found to be essentially more complicated here than in the case of a single equation, and it leads to restrictions on the S-matrix to make the existence of a short range potential possible. If such a potential exists, it is uniquely determined by the S-matrix, the eigenvalues, and as many real, symmetric, positive semi-definite matrices as there are eigenvalues. A.

530.145

5224. On the binding energy of H^3*. F. DUIMIO. *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 4, 688–93 (*April*, 1955) In Italian.

Very simple models have been used to calculate and compare the binding energies of the normal and excited deuteron and triton systems. These models take into account the general principles of the even-odd rule. The qualitative results, i.e. the low binding energy for H^3*, and the absence of bound states N_0–N_1 (D*) are in agreement with experimental results on unstable fragments. A.

530.145

5225. Approximate calculation of the second-order term in perturbation theory. P. KESSLER. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 10, 1058–60 (*March* 7, 1955) In French.

The evaluation of $\Delta \equiv \sum_{m \neq n} \langle m|V|n\rangle\langle n|V|m\rangle X$ is considered, where $X^{-1} \equiv E_m - E_n$ in a usual notation. The method depends on the introduction of an "average" $X \equiv \sum_{n \neq m} X|\langle m|V|n\rangle|^2 / \sum_{n \neq m} |\langle m|V|n\rangle|^2$.

P. T. LANDSBERG

530.145

5226. Vortex motions of the Madelung fluid. M. SCHÖNBERG. *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 4, 543–80 (*April*, 1955).

The general motions of the continuous medium (Madelung fluid), whose irrotational motions are described by the Schrödinger equation, are discussed. It is shown that many of the basic theorems of the vortex motions of the inviscid barotropic fluids are also valid for the Madelung fluid. A detailed discussion of the Clebsch parameters is given. It is shown that there is a special type of steady motions, similar to the Beltrami motions in which the streamlines coincide with the vortex-lines, which corresponds to a close generalization of the ordinary stationary states. The quantization of the vortex-tubes is discussed. Examples of Beltrami and discontinuous motions of the Madelung fluid are given. It is shown that the general motions of the Madelung fluid can also be physically interpreted in terms of the ordinary quantal states of a particle. A.

530.145

5227. A variation-perturbation method. I. L. COHEN. *Proc. Phys. Soc.* [*London*] *A*, **68,** *Pt* 5, 419–24 (*May*, 1955).

A perturbation procedure is used to improve to any order the approximate value obtained by the Rayleigh–Ritz variational method for the lowest eigenvalue of the one-dimensional Schrödinger equation. As an illustration of the method it is applied to the problem of the binding energy of the deuteron using central forces. A.

530.145

5228. A variation-perturbation method. II. L. COHEN. *Proc. Phys. Soc.* [*London*] *A*, **68,** *Pt* 5, 425–32 (*May*, 1955).

The method developed in Pt I is extended to simultaneous Schrödinger equations, and is applied to the problem of the binding energy of the deuteron with non-central forces. A.

530.162

5229. The transformation equations between one- and *n*-dimensional spectra in the *n*-dimensional isotropic vector or scalar fluctuation field. H. TSUJI. *J. Phys. Soc. Japan*, **10,** *No.* 4, 278–85 (*April*, 1955).

The transformation equations between one- and *n*-dimensional spectra in the *n*-dimensional isotropic vector or scalar fluctuation field are derived, the well-known equations for the three-dimensional fluctuation field being included as a special case. It is found that the transformation equation for *n*-dimensional vector fluctuations is of the same form as that for $(n + 2)$-dimensional scalar fluctuations except for the constant coefficient. The spectrum equations for *n*-dimensional isotropic turbulence and for *n*-dimensional isotropic temperature fluctuations in the *n*-dimensional isotropic turbulence are also derived. It is shown that the spectrum equations for any *n*-dimensional isotropic fluctuations have the same form. A.

530.162

5230. Partition function for a system of interacting Bose–Einstein particles. S. T. BUTLER AND M. H. FRIEDMAN. *Phys. Rev.*, **98,** *No.* 2, 287–93 (*April* 15, 1955).

It is shown by a rigorous development from first principles that a relatively simple form for the partition function of an imperfect Bose–Einstein gas can be obtained. This form is that of a $3N$-dimensional integral (N being the total number of particles) the integrand of which can be completely determined for any given interparticle interaction provided certain, in general small, many-body quantum mechanical effects are ignored. The final evaluation of the partition function in closed form requires that this integrand be approximated by functions sufficiently tractable that the $3N$-dimensional integral can be performed. A.

530.162

5231. Bose–Einstein condensation of an imperfect gas. M. H. FRIEDMAN AND S. T. BUTLER. *Phys. Rev.*, **98,** *No.* 2, 294–9 (*April* 15, 1955).

The form of the partition function for a system of interacting Bose–Einstein particles (preceding abstract) is treated approximately. A transition analogous to that occurring in the perfect gas is observed. The thermodynamic properties above and below this transition point are examined. A.

530.162 : 536.7

5232. The statistical mechanics of irreversible processes. IV. I. PRIGOGINE AND R. BINGEN. *Physica*, **21,** *No.* 4, 299–311 (*April*, 1955) In French.

Continues Pt III [Abstr. 2048 (1954)] and constitutes its generalized application to three-dimensional crystals. The equations of motion are first solved in terms of the initial positions and velocities. Thus, "influence functions" have to be defined, of which some asymptotic properties can be established. It is shown by means of these influence functions that the local distribution functions all tend to Gaussian distributions and the crystal to local homogeneity, whatever the initial distribution functions. The only assumption made concerns the absence of correlation at distances of the same order of magnitude as the dimensions of the crystal. Distribution functions are thus found, which are already very near to the equilibrium distribution and only depend on the second order cumulants (the first order cumulants being zero). It can similarly be shown that the second moments are quasi-invariant: after a more or less complicated variation, they tend to an asymptotic value which is not generally that of a crystal in thermodynamic equilibrium. These asymptotic values of the second moments correspond to statistical equilibrium only if initially the equipartition between the normal modes is realized without any correlation between their phases. No other condition is imposed; in particular the amplitudes of the normal modes need not have a Gaussian distribution. The behaviour of the local

distribution functions is characteristic of a kind of local ergodicity, in contrast with the non-ergodicity of the system as a whole. The thermodynamic consequences of this behaviour will be analysed in a subsequent paper. A.

530.162 : 539.3

5233. Statistico-mechanical theory of deformation, involving the activated state. W. J. LYONS. *Amer. J. Phys.*, **23**, *No.* 5, 268–75 (*May*, 1955).

The theory of deformation in matter which has been constructed by Eyring, his co-workers, and former pupils as an adaptation of the chemical reaction-rate theory is, in the present article, reviewed on the basis of concepts falling in the domain of physics in the more restricted sense. The theory of the physical phenomena of deformation, elasticity and flow is developed directly from statistico-mechanical fundamentals, without the introduction of concepts of chemical kinetics. Application of the basic theory to deformation in crystalline solids, as well as polymeric materials, is treated in some detail, and finally the work of numerous investigators who have contributed to the theory is briefly recounted. A.

GENERAL MECHANICS MECHANICS OF SOLIDS 531

531.252

5234. Stress functions and compatibility conditions of continuum mechanics. W. GÜNTHER. *Abhandl. Braunschw. Wiss. Gesell.*, **6**, 207–19 (1954) In German.

The stress state of a 3-dimensional continuum is represented geometrically as a curvature state of a "stress-space" whose curvature tensor $T_{iklm} = e_{ik\alpha}e_{lm\beta}S^{\alpha\beta}$, where $S^{\alpha\beta}$ is the stress tensor. It is shown that $T_{kl} - \frac{1}{2}g_{kl}T = S_{kl}$ and the analogy with the field equations of general relativity is discussed. The tensors T and S are expressed in terms of stress-function tensors [see Abstr. 460 (1949)] and the equations of equilibrium provide integrability conditions. See also Abstr. 5320 (1954). R. A. NEWING

531.252.2 : 518.5

5235. The solution of plane stress problems by an electrical analogue method. G. LIEBMANN. *Brit. J. appl. Phys.*, **6**, *No.* 5, 145–57 (*May*, 1955).

It is shown that the biharmonic equation $\nabla^4\chi = 0$, which Airy's stress function has to satisfy, can be solved by an electrical analogue comprising two resistance networks in cascade. Apart from the requirement of high accuracy of the solution for χ, as the stresses are to be obtained by numerical differentiation of the measured analogue data, difficulties arise through the unfavourable nature of the boundary conditions which have to be satisfied in many practical problems. These difficulties have been overcome by an experimental iteration method. Details are given of the technique of solving the biharmonic equation in this way for prescribed shape of the stressed body and prescribed forces acting on it. The solution is of the same type as that found by numerical methods, e.g. by relaxation, but it is obtained with much greater speed and facility. An accuracy in the evaluation of the stresses of 1 to 2% can be obtained; agreement with photoelastic measurements is very good. Examples are given of several problems which have been solved by the new method. The "cascaded network" technique can also be applied to the solution of other problems in elasticity, described by equations of the type $\nabla^4 w = f(x, y)$, e.g. the bending and extension of flat plates. A.

531.259

5236. Note on the solution of some problems of semi-infinite elastic solids with transverse isotropy. B. B. SEN. *Indian J. theor. Phys.*, **2**, *No.* 2, 87–90 (*Sept.*, 1954).

A simple method of solving problems of semi-infinite elastic solids with transverse isotropy and having symmetrical distribution of shearing stresses on the plane boundary is discussed in this paper. A.

531.551

5237. Maximum range of a projectile in a vacuum. C. D. BAKER AND J. J. HART. *Amer. J. Phys.*, **23**, *No.* 5, 253–5 (*May*, 1955).

A formula for the angle which produces maximum range of a projectile in vacuum on a spherical, non-rotating earth is derived. Initial velocities and altitudes are assumed to be such that the projectile returns to the earth. A.

MECHANICAL MEASUREMENTS 531.7

531.714

5238. History of electrical devices for measuring strains and small movements. B. E. NOLTINGK. *J. sci. Instrum.*, **32**, *No.* 5, 157–8 (*May*, 1955).

The development of apparatus for measuring strains and small movements by transduction into electrical signals is traced over the past hundred years. Instruments depending on resistive, capacitive, inductive, piezoelectric, acoustic and photoelectric systems are considered, and the chief contributors to the introduction of different techniques are enumerated. A.

531.714 : 548.0

5239. A single-profile crystal extensometer adjustable for orientation. A. J. KENNEDY. *J. sci. Instrum.*, **32**, *No.* 5, 183–5 (*May*, 1955).

The use of profile-type extensometers for the creep testing of metal single crystals of a fixed initial length is limited by the fact that a particular profile is required for any given original crystal orientation (ϕ_0). The device described uses a single profile which is set for ϕ_0 by simple rotation, the magnitude of this rotation being linear with ϕ_0. Crystals with values of ϕ_0 from zero to 50° can be tested with a stress variation of less than 1·5% over an extension of 100%. A.

531.717.1 : 621.317.39

5240. Resonance method of inspecting thickness and flaws. A. NOMOTO. Note in *Rev. sci. Instrum.*, **25**, *No.* 11, 1131 (*Nov.*, 1954).

The circuit diagram of a suitable oscillator is given and oscillograms showing the effect produced by a hole 1·6 mm dia. parallel to the surface of a 5·39 mm thick steel plate. The instrument can be used for measuring thicknesses of 0·15–200 mm.

G. F. HODSMAN

531.717.86

5241. An interferometer for "straightness" measurement. J. DYSON. Letter in *Nature* [*London*] **175**, 559–60 (*March* 26, 1955).

An interferometric system is described which is of use in checking the straightness of a mechanical motion such as that of a lathe-cutting tool. The system is based on two identical concave mirrors separated by their common radius of curvature. The reference straight is defined by a line joining the two centres of curvature. Between the mirrors is a Wollaston prism. A fringe system is formed which moves if the Wollaston prism is displaced at right angles to the axis but not for displacement in any other direction, and this is the straight. A sensitivity of 0·000 08 in. per fringe has been obtained.

S. TOLANSKY

531.74

5242. Instrument for the direct measurement of angles in the field of view of the naked eye. A. H. BOERDIJK. *Rev. sci. Instrum.*, **26**, *No.* 4, 382–3 (*April*, 1955).

The instrument described contains an illuminated scale of which a virtual image is formed at infinity by means of a spherical mirror and a glass plate. The image of the scale is superimposed on the normal field of view of the naked eye, enabling direct measurement of angles in that field. A.

531.752 : 541.183.5

5243. Further improvements to the vacuum torsion balance and sorption measurements on polystyrene. A. G. DAY. *Rep. Brit. Elect. Res. Assoc. Rep. L/T292*, 6 *pp.* (1953).

Descriptions of the means used to improve the accuracy of the balance are given; they include more accurate calibration and removal of the over-shoot [Abstr. 8542 (1951)] by reducing the radiometric forces acting on the specimen. Sorption measurements made on polystyrene at 50°C and up to 9·4 mm of mercury water vapour pressure have been repeated with greater accuracy and extended to enable surface sorption to be estimated. Diffusion coefficients calculated from the sorption-rate curves are some 1 000 times smaller than those calculated from sorption and permeability constant measured by Thomas and Gent (1944), indicating that Fick's law does not fully explain the sorption in polystyrene. A.

531.78 : 621.376.2 : 621.317.79

5244. Capacitive modulator for the measurement of forces. L. KUHN. *Slaboproudý Obzor*, **15**, *No.* 7, 327–34 (1954) In Czech.

The instrument consists of a capacitive test probe and electronic equipment comprising: an LC oscillator operating at 100 kc/s, a passive tuned LC circuit and a demodulator (detector) with a l.f. filter. The output voltage across the passive tuned circuit is proportional to the capacitance of the probe, since it provides a coupling between the oscillator and the LC tank. The probe is connected to the equipment by means of a doubly screened coaxial cable, whose outer sheath is earthed. A detailed theory of the capacitive-coupled circuit (modulator) is given; its unit step response and amplitude and phase characteristic are calculated. Design of a probe suitable for forces up to 300 kg, with a resonant frequency of 2·0 kc/s, is described in detail. Circuit diagram of the equipment and some performance curves are given.

R. S. SIDOROWICZ

531.787.6

5245. A tilting micromanometer with continuous sensitivity control. L. R. TAYLOR. *J. sci. Instrum.*, **32**, *No.* 5, 173–7 (*May*, 1955).

A null-reading liquid manometer is described in which the meniscus is returned to the reading position by varying the angle of slope. Sensitivity automatically decreases as the applied pressure increases; it is highest at zero readings and its absolute level can be continuously varied. A magnification factor can be employed by using different reading positions on the tube which is 0·1 in. bore, pivoted near the reservoir and tiled at its distal end by a standard micrometer-head, so keeping the construction simple and not critical. The prototype, which is wall-mounted, reads easily at air-speeds of 7·5 ft/sec with a Pitot-static tube; the highest limits of accuracy assessed are $\pm 0{\cdot}2$ dyn/cm², i.e. 6·5 ft/sec $\pm$ 0·5%. The upper reading limit is about 0·7 in. w.g. (50 ft/s). A.

MECHANICS OF FLUIDS 532

532.133 : 532.612.4

5246. Surface tension and viscosity of liquids. J. H. SIMONS AND W. H. WILSON. *J. chem. Phys.*, **23**, *No.* 4, 613–17 (*April*, 1955).

Empirical relationships have been found between energy of vaporization, surface energy, energy of activation of viscosity and the boiling temperature. This has been done by first considering the inert gases as the simplest type of liquid: $\Delta E_{vap} = \sigma_b A_b + \frac{1}{2}RT_b$, $\Delta E_{vis} = 1{\cdot}212RT_b^{1\cdot2}$. For the simplest type of polyatomic substance the normal fluorocarbons give $\Delta E_{vap} = \sigma_b A_b + \frac{1}{2}RT + 1{\cdot}212RT_b^{1\cdot2}$, $\Delta E_{vis} = 1{\cdot}212RT_b^{1\cdot2}$. The normal hydrocarbons give, as expected, liquids whose properties differ from those of the normal fluorocarbons: $\Delta E_{vap} = \sigma_b A_b + 1{\cdot}212RT_b^{1\cdot2}$, $\Delta E_{vis} = 1{\cdot}212RT_b^{1\cdot2} - 1\,000$. For normal heptane it is shown that $\Delta E_{vap} = \sigma A + 1{\cdot}212RT^{1\cdot2}$ may be taken at temperatures other than T_b. Suggestions are given for theoretical reasons for these equations. A.

532.133 : 536.421.4

5247. Viscosity anomaly of supercooled liquids. G. W. SEARS. Letter in *J. chem. Phys.*, **23**, *No.* 3, 604–5 (*March*, 1955).

To explain the anomaly in the ln ηv versus $1/T$ relation at m.pt. for supercooled liquids, it is assumed that stable rods of the solid phase exist in the supercooled liquid having grown from colloidal nuclei. Calculations based on measurements made with dispersions of fibres, etc., give results of the right order.

T. C. TOYE

532.517.2

5248. Laminar flow in channels with porous walls at high suction Reynolds numbers. J. R. SELLARS. Letter in *J. appl. Phys.*, **26**, *No.* 4, 489–90 (*April*, 1954).

The treatment of laminar flow in channels with

porous walls by Berman for the case of low Reynolds numbers [Abstr. 119 (1954)] is extended to the case of flows, characterized by very high Reynolds numbers, by a method which becomes asymptotically exact as the suction Reynold number, R_s, increases indefinitely. The complete solution involves solving the equation $f'''' = R_s(ff''' - f'f'' + k_1)$, where $f(\lambda)$ is the function defining Berman's stream function, $\psi = \bar{u}df(\lambda)(1 - x/L)$, and k_1 is determined from the associated boundary conditions. The solution is derived by a process of iteration. J. S. G. THOMAS

532.517.4 : 538.3

5249. The decay of magneto-turbulence in the presence of a magnetic field and Coriolis force. B. LEHNERT. *Quart. appl. Math.*, **12**, *No.* 4, 321–41 (*Jan.*, 1955).

The final period of decay of magneto-turbulence in an external, homogeneous magnetic field is considered and it is shown that it develops pronounced axi-symmetric properties, turbulence elements with finite wave-numbers in the direction of the field being damped strongly under normal physical conditions. The turbulence consists of aperiodic motions as well as wave motions. An introduction of an angular velocity, inclined to the field, destroys the axisymmetry and modifies the damping effects and periodicity. The influence of the magnetic field on the damping is counteracted by the Coriolis force. A linear stationary theory on the action of the field gives results consistent with those of the theory of decay. From the results of both theories an explanation is given of the observed inhibition of turbulence in mercury by a magnetic field. A.

532.517.4 : 538.3

5250. Magneto-hydrodynamics on cosmical and laboratory scale. B. LEHNERT. *K. Tekn. Högsk. Avhandl.*, *No.* 100, 19 *pp.* (1955).

A brief survey with special reference to theoretical and experimental work on waves and turbulence. Comments and errata for past and forthcoming papers by the author include notes on the paper reported in the preceding abstract. There is an extensive list of references. R. A. NEWING

532.525

5251. Re-examination of the nonsteady theory of jet formation by lined cavity charges. R. J. EICHELBERGER. *J. appl. Phys.*, **26**, *No.* 4, 398–402 (*April*, 1955).

A new type of analysis is applied to observations on jets from lined cavity charges in order to test the non-steady-state hydrodynamic theory of a jet formation. The results support previous findings that the theory is qualitatively accurate, but give evidence of departures from the ideal situation assumed in the theory. An attempt is made to assess one of the more likely sources of error, the neglect of acceleration of the liner. A.

532.57 : 621.317.39

5252. The electromagnetic measurement of velocities in liquids. G. REMENIERAS AND C. HERMANT. *Houille Blanche*, **9**, *Special No.* "*B*," 732–46 (*Nov.*, 1954) In French.

After outlining some of the principles the article describes three instruments which have recently been developed. A flowmeter for circular pipes gives 20 μV at 1 cm/sec before amplification and has a linear characteristic with a small zero error. A free-stream pitot tube of similar sensitivity operating up to 15 cm/sec has a curved characteristic and needs careful filtering of the 25 c/s energizing frequency owing to long leads. A disk-shaped "current meter" gives both direction and magnitude up to 1 m/sec with a sensitivity of 4·8 μV per cm/sec and a linear characteristic. Tests are in progress on a point flow meter consisting of a pair of electrodes which pick up the e.m.f. induced by a strong external magnetic field. P. LINTON

CAPILLARITY 532.6

532.6 : 536.7

5253. Arbitrary choice of the dividing surface in capillary layers not in equilibrium. R. DEFAY. *Bull. Acad. Roy. Belgique Cl. Sci.*, **41**, *No.* 2, 138–50 (1955) In French.

Shows that the thermodynamics of the plane capillary layer described with the aid of a Gibbs dividing surface may not always be applied to any dividing surface. The use of an arbitrary dividing surface is correct only when the chemical potentials satisfy two conditions. These two conditions are satisfied in the case of equilibrium, but out of equilibrium, the use of an arbitrary dividing surface involves a loss of generality. A.

532.61 : 530.162

5254. Spherical interface. II. Molecular theory. F. P. BUFF. *J. chem. Phys.*, **23**, *No.* 3, 419–27 (*March*, 1955).

For Pt I, see Abstr. 1514 (1952). The statistical mechanical theory of plane and spherical interfaces is developed on the basis of the virial theorem and the Gibbsian mechanical and thermodynamic definitions of surface tension. The expressions for the relevant thermodynamic functions in terms of molecular variables are employed in a discussion of the curvature dependence of surface tension which leads to an asymptotic expansion of the grand partition function in terms of the geometrical parameters that characterize the interface and thus provide a criterion for the range of validity of macroscopic concepts. A.

532.63

5255. Hysteresis of the angle of contact of mercury against steel. D. J. WRIGHT. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 5, 297–303 (*May*, 1955).

Experiments have been made to investigate some of the causes of the hysteresis of the angle of contact of mercury against steel. It is shown by experiments *in vacuo* and in gases at low pressures, that adsorption on the solid surface is a principal cause of hysteresis. In contrast to the results of earlier work, however, roughness does not affect the hysteresis, though the angles of contact themselves are altered. Some agreement with theoretical predictions is obtained. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.72

5256. On an optical method for the study of the Soret effect in ionic solutions. J. CHANU AND J. LENOBLE. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 9, 949–51 (*Feb.* 28, 1955) In French.

The principle of Young's fringes is used. The results obtained in several series of measurement with solutions of NaCl and of KCl agree among each other satisfactorily. H. LONDON

532.72

5257. Note on the fundamental law of diffusion. J. D. BABBITT. Letter in *J. chem. Phys.*, **23,** *No.* 3, 601–2 (*March*, 1955).

532.73

5258. The statistical thermodynamics of solutions of non-spherical molecules. II. Liquid-vapour equilibrium and the formation of azeotropes. J. S. ROWLINSON AND J. R. SUTTON. *Proc. Roy. Soc. A*, **229,** 396–404 (*May* 10, 1955).

The expressions derived in Pt I [Abstr. 4418 (1955)] are used to calculate the compositions of liquid and vapour phases and the conditions for the formation of an azeotrope in a binary mixture. It is found that the azeotropic composition of mixtures of non-spherical molecules changes more rapidly with temperature than that of a mixture of spherical molecules. A theory of solutions which includes the effects of non-central forces is necessary to explain the behaviour of those solutions which form azeotropes only over a limited range of temperature. These calculations are compared with measurements made on eight of the binary solutions formed from carbon dioxide, nitrous oxide, ethane, ethylene and acetylene. A.

532.74

5259. Problem of molecular association in liquid boron trifluoride. T. H. S. HIGGINS AND C. J. G. RAW. Letter in *J. chem. Phys.*, **23,** *No.* 3, 606 (*March*, 1955).

As previous evidence with respect to the association of BF_3 in the liquid phase is conflicting, the Ramsay Shields constant was calculated from density and surface tension data, on the assumption that it is a normal liquid. It was found to be 2·46 at boiling point. For normal liquids the value is 2·12, for associated liquids smaller. This points therefore to non-association as far as the surface properties are concerned, whilst properties related to forces between molecules point to association. A. J. TAYLOR

532.77

5260. Theory of protein solutions. I. T. L. HILL. *J. chem. Phys.*, **23,** *No.* 4, 623–36 (*April*, 1955).

A summary of a few results of the McMillan–Mayer solution theory is given in order to have available the equations required. It is pointed out that binding equilibria in a solution can in principle be discussed equally rigorously either implicitly or explicitly. The definition of "binding" in an explicit formulation is, strictly speaking, somewhat arbitrary but the arbitrariness disappears for practical purposes if the binding forces are very strong. However, the purely thermodynamic results are rigorously independent of the exact definition used. It is possible to formulate a general theory of protein solutions, including the effect of binding of ions or molecules on protein molecules. The discussion here is restricted to a single-protein species and a single type of molecule capable of being bound, but the generalization to any number of protein or bound species is easy and will be published later. The topics discussed are osmotic pressure virial expansion, number of bound molecules per protein molecule expanded in powers of the protein concentration, distribution functions for sets of protein molecules (including the radial distribution function), potentials of average force on sets of protein molecules, superposition approximation in relation to the osmotic pressure and the Born–Green–Yvon integrodifferential equation for the distribution functions, and, finally, the relation to the recent Kirkwood–Shumaker theory. The theory applies equally well to polyelectrolyte, colloidal, and other solutions, but the "protein" language is used throughout for definiteness. A.

532.77 : 530.162

5261. Remarks on the statistics of solutions. H. FALKENHAGEN AND G. KELBG. *Z. phys. Chem.* [*Leipzig*] **204,** *No.* 1–2, 111–14 (*Feb.*, 1955) In German.

An approximate expression is found for the concentrations of a binary solution of hard spheres in a field of force. The results are obtained by using the superposition approximation in a Born–Green type of equation and assuming that the particle volume (per unit volume) is small compared with unity. For a special case the formula reduces to that used by Eigen and Wicke [Abstr. 3967 (1952)]. R. O. DAVIES

532.787

5262. On the rate of nucleation in supersaturated solution. I. Some trials of the theoretical estimation of nucleation rate in electrolyte solution. K. HIRANO. *Sci. Rep. Tôhoku Univ. First Ser.*, **38,** *No.* 2, 97–103 (*Oct.*, 1954).

The modified Turnbull–Fisher equation is given for the nucleation process in the supersaturated electrolyte solution. Calculation of the nucleation rate for the case of potassium chloride solution was carried out. From the results it appears that the nucleation rate is essentially affected by the electric charges of the nucleus. A.

532.787

5263. On the rate of nucleation in supersaturated solution. II. Experimental determination of the crystallization temperature in the alkali halides solution and trials of the theoretical estimation of the temperature. K. HIRANO. *Sci. Rep. Tôhoku Univ. First Ser.*, **38,** *No.* 2, 104–16 (*Oct.*, 1954).

Making use of the results in Pt I, a theoretical formula for representation of the critical temperature of the nucleation T_c was given. Both theoretical and experimental estimations of T_c were performed for alkali-halide solutions, KCl, KBr, KI, NH_4Cl and NaCl. The comparison between two results, calculation and observation, shows that the theory agreed well with the experiments as far as the relative values of T_c are concerned. A.

MECHANICS OF GASES 533

533.15

5264. Self-diffusion of carbon tetrachloride, isobars and isochores. H. Watts, B. J. Alder and J. H. Hildebrand. *J. chem. Phys.*, **23**, *No.* 4, 659–61 (*April*, 1955).

The self-diffusion coefficient of CCl_4 has been measured over a range of temperature between 25 and 50°C and at 1 and 200 atm. The results can be expressed by the equations: for 1 atm., $D = 325 \exp(-3\,300/RT)$, for 200 atm., $D = 264 \exp(-3\,300/RT)$. The activation energy for constant volume is 1 070 Cal. These activation energies are identical with those previously found for the diffusion of I_2 in CCl_4. The temperature coefficient of diffusion at constant volume parallels in both cases the increase of kinetic energy. $D\eta/T$ is constant within 7% in the range studied, where η denotes viscosity. These results are discussed in relation to various theories for the mechanism of diffusion. A.

533.21

5265. The compressibility of gases at high temperatures. X. Xenon in the temperature range 0° to 700°C and the pressure range 8 to 50 atmospheres. E. Whalley, Y. Lupien and W. G. Schneider. *Canad. J. Chem.*, **33**, *No.* 4, 633–6 (*April*, 1955).

For Pt VII, see Abstr. 4250 (1954). The virial coefficients of xenon have been measured in the temperature and pressure range described. The results are compared with previous measurements. A.

533.5 : 531.788.7

5266. Desorption of gas in the cold cathode ionization gauge. E. Brown and J. H. Leck. *Brit. J. appl. Phys.*, **6**, *No.* 5, 161–4 (*May*, 1955).

Desorption of gas by positive ion bombardment has been studied. Mass spectrometer measurements have shown an interesting exchange process to take place at the cathode of the gauge. Incident ions with an energy of the order of 1 000 eV drive off molecules already trapped at the surface and are themselves adsorbed. In addition to a careful study of this phenomenon a further clean-up mechanism has been noticed, in which gas is held in the interior of the electrodes. These two clean-up reactions take place simultaneously. These phenomena are probably not confined to the cold cathode ionization gauge but take place whenever surfaces are exposed to ion bombardment and are therefore of fairly general interest. A.

533.5 : 621.316.71

5267. Ion-gage supply protects tubes. R. W. Raible and M. K. Testerman. *Electronics*, **28**, *No.* 2, 210, 212, 214, 216, 218 (*Feb.*, 1955).

Describes a portable ionization-gauge tube supply which can be quickly connected to an ionization-gauge previously sealed into a vacuum system and thus easily movable from one vacuum system to another. The emission of the gauge tube filament is regulated by a temperature change of the filament due to change in gas pressure and also fluctuation in line voltage. The regulator is actuated by a change in voltage across two resistances through which the ion-gauge grid current passes. After amplification this signal is passed to the control grids of two valves which in effect alter the load condition on the transformer supplying the gauge tube filament and thus alters the voltage applied to this filament. A circuit and description of operation is given. By providing certain adjustments, the supply can be used for practically any type of ionization-gauge tube. B. B. AUSTIN

533.5 : 621.385.032.46

5268. Barium getters in carbon monoxide. J. Morrison and R. B. Zetterstrom. *J. appl. Phys.*, **26**, *No.* 4, 437–42 (*April*, 1955).

The effects of pressure, temperature and physical state on the ability of a barium getter to sorb carbon monoxide are presented. At pressures in the 10^{-5} mm range, a five-milligram getter is exhausted in about one thousand hours. Temperatures ranging from room temperature to 150°C did not affect greatly the rate of gettering or the capacities of the getters. The observed gettering rates or capacities do not obey any simple law over an extended time. A.

533.5 : 669.791

5269. Technology and application of mercury in vacuum technique. W. Espe. *Slaboproudý Obzor*, **16**, *No.* 1, 37–44 (1955) In Czech.

The method of producing Hg from HgS is briefly outlined and the processes involved in its purification, for the purpose of vacuum application, are surveyed. Physical and chemical properties of Hg, the safety measures to be adopted in working with Hg and its application in high-vacuum and electronic devices are reviewed. Various data relating to Hg are reported in 5 tables: (1) the purification procedure; (2) physical constants; (3) vapour pressure and evaporation velocity as a function of temperature; (4) viscosity as a function of temperature, and (5) chemical properties. The paper contains 48 references.

R. S. SIDOROWICZ

533.59

5270. Use of A^{37} to determine argon behavior in vacuum systems. D. R. Carr and J. L. Kulp. *Rev. sci. Instrum.*, **26**, *No.* 4, 379–81 (*April*, 1955).

By employing A^{37} as a tracer it has been possible to show that quantities of argon as small as 10^{-9} cm^3 can be circulated in a vacuum system containing furnaces, charcoal traps, electrical discharges, and stopcocks without measurable loss of argon. Further, it is shown that argon is not desorbed from charcoal at liquid air temperatures in appreciable quantities during prolonged evacuation. A.

MOLECULAR THEORY OF GASES 533.7

533.7

5271. Molecular clusters in imperfect gases. T. L. Hill. *J. chem. Phys.*, **23**, *No.* 4, 617–22 (*April*, 1955).

An exact, formal method for calculating the number of physical (as contrasted with Mayer's mathematical) clusters in an imperfect monatomic gas is developed. However, although the equations are exact, the definition of a physical cluster is somewhat arbitrary. This arbitrariness does not affect any of the purely thermodynamic properties of the gas. A

particular pair-wise definition of physical clusters is discussed in some detail and compared with Mayer's pair-wise definition of mathematical clusters. A.

533.7

5272. Virial coefficients and intermolecular potential of helium. T. KIHARA, Y. MIDZUNO AND T. SHIZUME. *J. Phys. Soc. Japan*, **10**, *No.* 4, 249–55 (*April*, 1955).

The intermolecular potential of helium has been determined from an analysis of the second and the third virial coefficients above the Boyle temperature, where the virial coefficients can be expanded into power series on h^2, the square of Planck's constant. The series have been calculated up to the term proportional to the third power of h^2 in case of the second virial coefficient and up to the term proportional to the first power of h^2 in case of the third virial coefficient. The following conclusion has been drawn. The two-body system of He^4 atoms has a discrete energy level while the two-body system of He^3 atoms has no discrete level. A.

VIBRATIONS . ACOUSTICS 534

534.213 : 537.228.1 : 535.343

Submicrowave domain resonances in piezoelectric crystals. *See Abstr.* 5319

534.22/.23

5273. Absorption and velocity of sound in vapors. E. G. RICHARDSON. *Rev. mod. Phys.*, **27**, *No.* 1, 15–25 (*Jan.*, 1955).

A review of the work on this subject during the past fifteen years. The paper deals with the theory of interferometers of the Pierce type, double crystal, capillary tube and hot-wire types. Results are discussed of measurements at varying pressure in air, rare gases, triatomic molecules, and polyatomic molecules (organic vapours). The effect of temperature and of mixtures of vapours are discussed. Observations of velocity and absorption near the critical state for CO_2 as a function of pressure and frequency are dealt with in a later section of the paper, which also refers to the derivation of thermodynamical relations and to the propagation of shock waves in vapours. The paper concludes with a useful list of 100 references to current literature. A. B. WOOD

534.22

5274. The dispersion of ultrasound velocity in $MnSO_4$ solutions. N. S. TAŞKÖPRÜLÜ. *Rev. Fac. Sci. Univ. Istanbul C*, **19**, *No.* 4, 331–4 (*Oct.*, 1954).

The velocity dispersion in aqueous solutions of $MnSO_4$ has been measured at 5 and 15 Mc/s using the double-cell method which has been described in a former paper. The results for the relative dispersion $D = [(v_{15}-v_5)/v_5]10^3$ are $0{\cdot}8 \pm 0{\cdot}4$; $1{\cdot}7 \pm 0{\cdot}3$ and $0{\cdot}9 \pm 0{\cdot}3$ for the concentrations 0·5; 1·0 and 2·0 mol/litre respectively. A.

534.22 : 539.32

5275. A magnetostrictive oscillator for measuring elastic wave velocities in small rods. N. B. TERRY AND H. J. WOODS. *Proc. Leeds Phil. Lit. Soc.*, **4**, *Pt* 4, 251–3 (*Dec.*, 1954).

Describes a circuit by means of which magnetostrictive oscillations can be maintained in small nickel rods or wires. Using composite oscillators, in which specimens are cemented to the end of a nickel transducer, the velocity of elastic waves in crystalline rods 5 mm long and about 0·5 mm in width and thickness has been measured. A.

534.222.1

5276. Velocity of ultrasound in systems of partially miscible liquids. M. CEVOLANI AND S. PETRALIA. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 705–16 (*April*, 1955) In Italian.

Using ultrasonic interferometry measurements have been made at 3 Mc/s frequency in systems of phenol–water, cyclohexane–methanol, carbon disulphide–methanol, aniline–cyclohexane. With density measurements the compressibility of the mixtures has been determined at different concentrations as well as Rao's molecular velocity and the changes in volume on mixing. The experimental results are discussed in the light of modern ideas on the propagation of ultrasonics in liquids. Generally in these mixtures compressibility results are higher than one could foresee for ideal mixtures, the molecular cohesion energy reducing itself in the mixture. For the system phenol–water one notices also, by low molecular concentration of phenol a slight decrease of compressibility; for the system aniline–cyclohexane the compressibility seems to change rectilinearly. Experimental values of the Rao velocity are very near those theoretically calculated. A.

534.222.2

5277. Shock waves in a medium in a state of relaxation. S. P. D'YAKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 6(12), 728–34 (1955) In Russian.

534.222.2 : 538.566

5278. Measurement of detonation velocity by Doppler effect at three-centimeter wavelength. M. A. COOK, R. L. DORAN AND G. J. MORRIS. *J. appl. Phys.*, **26**, *No.* 4, 426–8 (*April*, 1955).

The method makes use of the ionized wave front in detonation as a moving reflecting surface for electromagnetic waves. Detonation velocities for four different solid explosives were calculated from the observed Doppler frequencies and the indices of refraction, which were measured by a microwave interferometer. Complexities in the observed Doppler patterns come about because the cylindrical charges act as multimode dielectric waveguides. A.

534.222.2 : 539.3

5279. Properties of elastic and plastic waves determined by pin contactors and crystals. S. MINSHALL. *J. appl. Phys.*, **26**, *No.* 4, 463–9 (*April*, 1955).

Experimental techniques are described by which one can observe the separation of a shock wave in a metal into an elastic wave and a slower plastic wave. The plastic-wave velocity was about 15% less in steel and 10% less in tungsten than the elastic-wave velocity, at pressures imparted by Composition B explosive. Elastic-wave velocities were the same, within experimental error, as the measured sound velocities. The pressure in the elastic wave in SAE 1020 steel, deduced from the material and wave velocities, is independent of the plastic-wave pressure within experimental accuracy, and is about 12 kilobars. SAE 1040 steel, however, does not exhibit a single characteristic elastic-wave pressure. The pressure

initially is about 6 kilobars, and increases to about 12 kilobars before the arrival of the plastic wave. A.

534.23

5280. Determination of the ultrasonic absorption coefficient of benzol with thermal method. E. Grossetti. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 525–6 (*April*, 1955).

Measurements made at 1·8 Mc/s are reported. The value obtained for α is much higher than the theoretical one. This anomaly could be ascribed to the high value of the second volume viscosity coefficient, determined by Liebermann. A.

534.23 : 532.7

5281. Ultrasound absorption and association in solutions of phenol in CCl_4 and C_6H_{12}. W. Maier and A. Mez. Note in *Z. Naturforsch.*, **10a**, *No.* 2, 167–8 (1955) In German.

An investigation of the maxima in absorption coefficient at small concentrations of phenols or alcohols. A number of observations have been made using an improved optical method at a frequency of 20 Mc/s in the temperature range 15 to 50°c with an accuracy in α/ν^2 of $\pm 5\times10^{-17}$ cm^{-1}sec^2. The maxima are explained assuming the absorption to be an additive property involving mainly the normal oscillation relaxation and also the relaxation of the association equilibrium of the phenol. T. C. Toye

534.23 : 532.7

5282. On the theory of sound absorption in associated liquids. T. A. Litovitz and E. H. Carnevale. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 379 (*March*, 1955).

Measurements of absorption of ultrasonics in water and some alcohols give results contrary to those predicted by Hall's theory. Modification of the latter is very briefly suggested, further details are to be published. T. C. Toye

534.23 : 537.228.1

Effect of temperature and acoustic impedance of vapours on the electrical constants of quartz. *See Abstr.* 5398

534.232 : 621.395.623.7 : 621.395.61

5283. Comments on the invited paper "Loudspeakers and microphones" by Leo L. Beranek. B. F. Miessner. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 381–2 (*March*, 1955).

See Abstr. 138 (1955). The author draws attention to a number of errors and omissions in Beranek's paper. These refer mainly to inventions and dates of origin of various devices mentioned in the paper, e.g. "rocking armature driving unit," "folded horn," "ribbon microphones," "directional diaphragms," "condenser microphones," the "electro-mechanical analogy," etc. A. B. Wood

534.24

5284. Reflection of sound in the ocean from a continuous stratum containing a velocity extremum. E. O. Cook and H. S. Heaps. *J. appl. Phys.*, **26**, *No.* 4, 429–33 (*April*, 1955).

The reflection of a plane wave of sound from a layer separating regions of different sound velocities, the layer itself containing a velocity variation through an extremum, is considered in terms of its dependence upon the angle of incidence, the layer thickness, and the velocity variation through the layer. It is found that the power reflection coefficient may differ significantly from its value for the corresponding abrupt monotonic velocity transition. Numerical results are tabulated for various types of layers of thickness from zero to ten wavelengths and with a total velocity transition of ±5 and ±10 ft/sec. A.

534.24

5285. Glancing angle reflection of elastic waves from a free boundary. F. C. Roesler. *Phil. Mag.*, **46**, 517–26 (*May*, 1955).

The usual treatment of the reflection of an irrotational wave from a free boundary results for glancing incidence in a seemingly trivial solution where all motion and stress vanishes. In experiment a pressure pulse made to travel at glancing angle along a free boundary trails a shear pulse, but this is properly speaking a diffraction phenomenon, the free boundary beginning at some finite distance. Though this diffraction process cannot be described completely in terms of the reflection treatment, it is possible, by using a limiting process and by changing the interpretation of the variables, to obtain in these terms the asymptotic state far down the free boundary. The result accounts for the trailing shear pulse and is amenable to experimental check. A.

534.24

5286. Reflection of elastic waves from a free boundary. D. G. Christie. *Phil. Mag.*, **46**, 527–41 (*May*, 1955).

A dilatation wave incident on a free surface produces reflected dilatation and distortion waves. The relation between the amplitudes of these waves has already been calculated when the reflection occurs at the surface of an elastic half-space. It is shown that a similar relation holds for a plane pulse travelling in a plate and reflected from a free edge. An experimental method is described for investigating this reflection problem, together with the results obtained. Agreement between experiment and the classical reflection theory is found to be good, provided that care is taken in defining the observed variables. At glancing incidence the phenomenon should be considered as one of diffraction; however Roesler (preceding abstract) has shown that by suitable choice of variables an explanation is possible in terms of reflection theory. His results are found to be in agreement with experiment. A.

534.25 : 537.312.5

5287. Photoelectric measurement of low acoustic birefringence. J. Badoz. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1062–4 (*March* 7, 1955). In French.

A photoelectric method has been devised, in which the ultrasonic wave of 3·5 Mc/s is modulated at 1 300 c/s. The consequent modulation of the birefringence and of the photocell output permits selective amplification and the undesirable influence of parasitic phenomena is thus reduced, resulting in highly accurate measurements. T. C. Toye

534.321.9

5288. Visual display of ultrasonic waves and applications. M. F. Canac. *J. Phys. Radium*, **16**, *No.* 3, 3 S–6 S (*March*, 1955) In French.

The stroboscopic method of observing ultrasonic

waves has the advantage of not disturbing the field. The method has been used in a number of cases demonstrating interference. There are a number of photographs showing the effects observed, including that of multiple reflections between plane mirrors and also reflections inside a cylindrical mirror, as a demonstration of the whispering gallery effect. T. C. TOYE

534.321.9 : 534.862.4

5289. Some new results on the demodulation in air of two ultrasounds of different frequency of which one at least is in the stationary state. S. KLEIN. *Ann. Télécomm.*, **10**, *No.* 2, 26–9 (*Feb.*, 1955) In French.

It has been suggested that this effect, previously reported [Abstr. 4294 (1954)] is due to the non-linearity of the ear and that an objective sound is not created in the air-space, as suggested by the author. A number of experiments are described which confirm the earlier observations and the author suggests that this supports his hypothesis. G. F. HODSMAN

534.372

5290. Rayleigh's principle in the case of damped oscillations. F. H. VAN DEN DUNGEN. *Bull. Acad. Roy. Belgique Cl. Sci.*, **40**, *No.* 11, 1038–45 (1954) In French.

An extension of a previous analysis of flexural vibrations of a beam [Abstr. 3937 (1953)] to the case when there are frictional losses leads to a generalization of Rayleigh's principle. J. G. OLDROYD

534.522.1

5291. Ultrasonic grating remaining after stopping the supersonic waves. V. A. CARRELLI AND F. PORRECA. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 527–31 (*April*, 1955).

Continuing previous work [Abstr. 2181 (1954)] the dependence of the effect on the frequency is shown. Moreover, the duration t_p in the suspensions containing particles with different mass, centrifugally separated shows clearly that the effect is bigger in the suspensions with particles of lesser mass, at the same concentration. Then, the line persistence increases with increasing contact surface between particle and liquid. A.

534.522.1

5292. Behaviour of suspensions crossed by a small light beam modulated by ultrasonics. F. FANTI AND F. PORRECA. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 532–6 (*April*, 1955).

Continues the study of the change of light intensity along the diffracted image of the slit, caused by the passage through liquids subjected to ultrasonics, of a monochromatic light beam, the thickness of which equals the supersonic wavelength [see Abstr. 2388 (1953)]. The distribution in the liquid suspensions, in which the diffracted lines persist after stopping the ultrasonics, is unlike the one in substances not showing this effect. Moreover, the first suspensions, showed two different diffraction patterns by displacing the supersonic grating of $\lambda_{u.s.}/4$, at right angles with the light direction. A similar experiment has been made by coupling two model phase gratings (parallel slits cut in a Plexiglas plate) and results obtained like the one in suspensions which show the persistence effect. This supports the assumption that such an effect is due to the building of a second phase grating, formed by the suspended particles accumulated in the nodal planes of the supersonic phase grating. A.

534.7

Physiological acoustics. Hearing. *See also under* "Medical science. Human physiology." Decimal classification 612.85

534.773 : 612.858.751 : 621.395.92

5293. Stereophonic hearing with one earphone. J. C. MOUZON. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 381 (*March*, 1955).

An important problem for the wearer of a hearing aid is the inability to select a particular sound source out of a combination of several sources of sound—resulting in confusion and difficulty when the wearer is, for example, in a group of people all of whom are talking at once. Experiments by the author appear to indicate that a single earphone supplied by two receiver microphones can be used by the wearer to distinguish differences of quality and direction of sound-source. In the latter case the directional effect is considered to be due to time-difference of arrival at the two microphones. A. B. WOOD

OPTICS . RADIATION . SPECTRA 535

535.14 : 538.3

5294. The representation of the electromagnetic field of arbitrary frequency with the help of the model energy quantum. H. ZUHRT. *Arch. elekt. Übertragung*, **8**, *No.* 12, 565–77 (*Dec.*, 1954) In German.

A detailed interpretation of wave fields, static fields and electromagnetic quantities in terms of the author's model quantum [Abstr. 3536 (1955)]. R. A. NEWING

535.247

5295. Measurement of the luminous energy of impulse-type sources of light. YU. M. KUTEV. *Elektrichestvo*, **1955**, *No.* 1, 66–8. In Russian.

A laboratory model of a portable photometer specially designed for measuring the angular distribution of the luminous energy of impulse and flash lamps, etc., is described. The measuring range is 10^{-2} to 10^4 candle-seconds. The instrument, called an integrating lumen-meter, enables impulse lamps giving flashes of durations from 10 microsec to 0·1 sec, and of a maximum dimension of the luminous phenomenon of 100 mm to be examined. The principle of the instrument is as follows: the light of the source passes through a tele-centric optical system and falls on the cathode of a Sb–Cs photoelement, after passing a filter which reduces the spectral sensitivity of the photoelement to that of the human eye; the photocurrent charges a capacitor inserted in the circuit of the photoelement. The calibration of the instrument as well as a circuit enabling identical optical pulses of equal duration to be obtained are also described in the paper. B. F. KRAUS

535.317.1

5296. Variation in distortion with magnification. A. A. MAGILL. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 3, 135–42 (*March*, 1955).

For abstract, see Abstr. 2551 (1955).

535.317.4 : 535.42

5297. The influence of spherical aberration upon the structure of diffraction figures of revolution. G. Lansraux. *Rev. Opt.*, **34**, *No.* 2, 65–91 (*Feb.*, 1955) In French.

Expressions are derived for the intensity distribution in the diffraction image formed by an optical system with circular aperture, suffering from spherical aberration. The energy within a circle of radius W, denoted by $E(W)$ is found as a proportion of the total energy in the pattern, and also its variation with position of focus and amount of aberration. Methods of numerical computation of $E(W)$ are given.

R. W. FISH

535.317.6

5298. The analytical design of a triplet and its modifications. M. Malý. Letter in *Czech J. Phys.*, **5**, *No.* 1, 94–6 (*Feb.*, 1955) In German.

A method of determining the lens parameters, radii of curvature, separations, etc., from the solution of equations based upon the Seidel coefficients of aberrations. The further application of the method to a triplet with an additional meniscus is described.

R. W. FISH

535.318

5299. Choice of glasses for achromatizing a thin visual objective. F. Blottiau. *Rev. Opt.*, **34**, *No.* 2, 92–102 (*Feb.*, 1955) In French.

Optical design of thin doublets or triplets is normally based upon the refractive index N_D and the V number of the glass. The refractive index is not a linear function of wavelength, and a third constant needs to be introduced, if the spectral energy distribution of the incident light and the receptor sensitivity are to be taken into account. A method of computation is suggested and applied to the selection of glasses from common types.

R. W. FISH

535.33.03

5300. Suppression of AlO in the wake of ultraspeed pellets. W. C. White. *Astrophys. J.*, **121**, *No.* 1, 271–6 (*Jan.*, 1955).

Time-resolved spectrograms of aluminium ultraspeed pellets have been obtained along their trajectories. The AlO bands were observed to be suppressed for a length of time depending upon the position of the pellet along its trajectory. The time of suppression is a few microseconds at the beginning of the trajectory, reaches a maximum of about 180 microseconds at 1·8 metres, and goes to 5 microseconds at approximately 3·5 metres.

A.

535.33.03 : 536.46

5301. Experimental evidence for the existence of abnormal OH rotational "temperatures" in low-pressure flames. H. P. Broida and H. J. Kostkowski. Letter in *J. chem. Phys.*, **23**, *No.* 4, 754 (*April*, 1955).

The high effective temperatures reported by Gaydon and Wolfhard and attributed to non-thermal excitation were questioned by Penner as possibly due to errors caused by self-absorption. Self-absorption is now shown to be negligible and further measurements also give very high temperatures. The OH absorption has been measured directly, using a background source giving fine OH lines, and by a two-path method.

A. G. GAYDON

535.33.07

5302. Low-temperature absorption cell for the Cary recording spectrophotometer. F. E. Geiger, Jr. *Rev. sci. Instrum.*, **26**, *No.* 4, 383–4 (*April*, 1955).

A metal absorption cell is described for the measurement of absorption spectra of alkali-halide crystals at low temperatures. The cell is specifically designed for the Cary automatic-recording spectrophotometer. The crystal holder of the cell can also be heated electrically to several hundred degrees centigrade for crystal bleaching experiments, or rotated out of the spectrometer beam to expose the crystal to X-rays. Design and performance data are given.

A.

535.33.07 : 545.822

5303. A double-beam method of spectral selection with flames. C. T. J. Alkemade and J. M. W. Milatz. *Appl. sci. Res. B*, **4**, *No.* 4, 289–99 (1955).

A non-dispersive, optic-electrical filter instrument is described, which combines high spectral resolving power (~0·1 Å) with large luminosity, at wavelengths which are of interest in spectrochemistry. The method is based on the balance of two light-beams emitted by a source S, which are periodically chopped in opposite phase. By placing a flame A containing vapour of some element into one light-beam, this balance is made critical for wavelengths that are specifically absorbed by this vapour. The applicability of a self-radiating flame as absorber could be realized by making use of an a.c. measuring device and by choosing a suitable position of the light-chopper. The described test experiments, which were made with a provisional instrument, prove the applicability of this method, especially in flame photometry.

A.

535.331

5304. Isotope shifts and hyperfine structure in the atomic spectrum of tin. W. R. Hindmarsh and H. Kuhn. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 433–8 (*May*, 1955).

The spectrum of tin was excited in a liquid oxygen cooled hollow cathode tube, and examined by means of a Fabry–Perot interferometer. With the use of highly enriched samples of tin isotopes, isotope shifts of all the even isotopes were measured in the spark line $5s^2 6s\,^2S_{1/2}$–$5s^2 6p\,^2P_{3/2}$, λ6454. The shifts between successive even isotopes vary from 0·001 5 cm^{-1} for Sn^{122} and Sn^{124} to 0·006 7 cm^{-1} for Sn^{112} and Sn^{114}, and this change occurs in two "jumps." The probable error is about 0·000 2 cm^{-1}. The corresponding isotope shift constants (C values), calculated without allowance for the specific mass shift, vary from 15×10^{-3} cm^{-1} to 40×10^{-3} cm^{-1}. The hyperfine structures of the line λ6454 of the odd isotopes Sn^{117} and Sn^{119} were measured. The ratio of the splittings is 1·042, in good agreement with the value 1·046 calculated from the nuclear resonance values of the nuclear magnetic moments.

A.

535.332 : 535.337

5305. The Stark effect in hydrogen. L. A. Prinsloo. Note in *Naturwissenschaften*, **42**, *No.* 4, 93–4 (1955) In German.

Results seem to point to a common displacement of the centres of gravity of all electron states in a transverse electric field.

G. E. BROWN

535.332

5306. Vacuum wave-length measurements in the ultra-violet spectrum of isotope neon-20. J. BLACKIE AND T. A. LITTLEFIELD. *Proc. Roy. Soc. A*, **229**, 468–72 (*May* 24, 1955).

The vacuum wavelengths of 21 lines in the spectrum of $_{10}Ne^{20}$ have been measured in the region 3 376 to 3 756 Å using a reflecting echelon interferometer. Since the standard error is rather less than $\pm 0{\cdot}000\,1$ Å and this is supported by an examination of inter-level differences, the wavelengths have been expressed to eight significant figures. A.

535.332

5307. Electron excitation functions of infra-red nitrogen spectra. D. T. STEWART. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 404–8 (*May*, 1955).

The relative excitation functions of lines and bands in the near infrared spectrum of nitrogen have been determined using photographic photometry. The maximum of intensity of the (2, 0) and (3, 1) Meinel bands of N_2^+ occurs at 60 V while that of the NI lines at 8 200 Å resulting from the $3s^4P$–$3p^4P^0$ transition occurs at 90 V. A.

535.333

5308. Band spectrum of CrF molecule. B. KANAKA DURGAVATHI AND V. RAMAKRISHNA RAO. *Indian J. Phys.*, **28**, *No.* 11, 525–32 (*Nov.*, 1954).

Two band systems (I and II) attributable to the CrF molecule were obtained in emission in a heavy current discharge in the regions $\lambda\lambda$4230–4470 Å and $\lambda\lambda$3830–4050 Å respectively. System I was interpreted as due to the electronic transition $^6\Pi \rightarrow {}^6\Sigma$ and system II as due to a transition $^6\Sigma \rightarrow {}^6\Sigma$ with a common lower state. The ω_e'' value is observed to be approximately 520 cm^{-1}. A.

535.333

5309. Rotational structure of the emission bands of formaldehyde. M. FAURIS. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1074–6 (*March* 7, 1955) In French.

The emission spectrum in a discharge tube has been examined by a spectrograph with a dispersion of 30 Å/mm in the region about 4 000 Å. Tables are given of calculated and measured wave-numbers of the lines observed. The calculated values are based on the assumption of a symmetric-top molecule, allowance being made for the Coriolis factor in the lower level of a transition. A. J. TAYLOR

535.338.334

5310. Quantum theory of line broadening by an ionic plasma. H. MARGENAU AND R. MEYEROTT. *Astrophys. J.*, **121**, *No.* 1, 194–203 (*Jan.*, 1955).

It is shown how Holtsmark's theory is related to first principles of line broadening, and its connection with other so-called "statistical" theories is indicated. The quantum-mechanical derivation is restricted to perturbations by a single ion but retains the terms which correspond to the non-uniformity of the field. Ions and electrons are treated simultaneously, and the shifts caused by the electrons are computed in a simple manner. Unpublished work dealing with line broadening by electrons, not included in this paper, is briefly summarized; it is noted that broadening as well as shifts by electrons amount to only a few per cent of the ion width. While the method employed is applicable to all hydrogen lines, the details are given only for the Lyman-α line. A.

535.338.334

5311. Electron impact broadening of spectral lines. B. KIVEL, S. BLOOM AND H. MARGENAU. *Phys. Rev.*, **98**, *No.* 2, 495–514 (*April* 15, 1955).

Ion densities in electrical discharges and in stars are often determined by observing the widths of spectral lines emitted or absorbed. The Holtsmark theory, usually employed in the interpretation of the data, restricts itself to ions and ignores electron collisions, which are treated in a qualitative way. This paper describes a detailed theory of electron effects upon the Lyman-α line. A convenient physical classification of the result is as follows. Electrons produce, first of all, a *universal* line effect, a broadening occurring regardless of the nature of the atomic transition. Its cause is the transfer of energy from the electrons to one or the other of the two atomic states via scattering. So far as the analogy is proper, this effect is what is sometimes called "second-order Stark broadening." It forms the predominating feature when a linear Stark effect is absent. Secondly, electrons can enforce the optical transition by collisions of the second kind. This mechanism, called *quenching*, broadens the line. It alone has the property of reducing the intensity of the line under normal conditions. A third possible contribution to the line width results from *polarization*, the counterpart of a first-order Stark effect. It comes about if one of the atomic states (the upper in this example) is degenerate or nearly degenerate. The electron, while flying past the atom, can then induce transitions without much energy transfer, i.e. polarize the atom. A distinction is made between (*a*) polarization through induction of a temporary dipole moment and (*b*) polarization through reorientation of an atomic dipole already present by virtue of a neighbouring ion. The first of these is a large effect; its calculation requires the removal of divergences which are ordinarily encountered in the matrix elements. The summary at the end of the paper contains numerical results on the broadening of L_α by these several agencies under conditions approximating the solar photosphere. They are all small in comparison with Holtsmark broadening by ions. But the example is unusual; in general the electron effects are far from negligible. A.

535.338.42

5312. Study of the infrared spectrum of compressed mixtures of gaseous hydrogen chloride and hydrogen and the appearance of a combination frequency between HCl and H_2. R. COULON, J. ROBIN AND B. VODAR. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 956–8 (*Feb.* 28, 1955) In French.

Under pressure, combination bands sometimes appear which are forbidden under ordinary conditions, but so far HCl mixtures had never shown this phenomenon. Here H_2 at pressures up to 800 atm was mixed with HCl (160 amagats) and the spectrum of the mixture investigated. An absorption band with centre at 7 050 cm^{-1} was observed. This frequency fits the combination of the 2 886 cm^{-1} HCl and 4 155 cm^{-1} H_2 bands. Similar bands were found in mixtures of HCl with N_2 and with O_2. An increase in absorption in the region of the second harmonic of

HCl was also found. The frequency of this harmonic does not differ much from that of the first harmonic of H_2. A. J. TAYLOR

535.338.42

5313. On the vibration-rotation spectrum of a system of two diatomic molecules in electrostatic interaction. L. GALATRY AND B. VODAR. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 10, 1072–4 (*March* 7, 1955) In French.

The case of a mixture of a polar with a non-polar gas is considered, and leads to a suggested explanation for the appearance of the fundamental frequency of the non-polar gas, and of the combination frequency. See also preceding abstract. R. F. BARROW

535.342

5314. Formation of absorption lines. J. W. WARWICK. *Astrophys. J.*, **121,** *No.* 1, 190–3 (*Jan.*, 1955).

The proposed new equation gives a phenomenological description of the combination of thermal emission and scattering in the formation of an absorption or emission line. A feature of the equation is the dependence of thermal emission on the radiation field. The equation reduces to the standard ones for line formation if one assumes a two-state atom. Finally, the constancy of ε in the Milne–Eddington equation is shown to imply a definite excitation temperature. A.

535.343

5315. Studies of absorption spectra. VII. Systems with three and more *f*-electrons. C. K. JØRGENSEN. *K. Danske Vidensk. Selsk., mat-fys. Medd.*, **29,** *Paper* 11, 29 *pp.* (1955).

For Pt VI, see Abstr. 4527 (1955). An investigation into the atomic energy levels of the lanthanide and actinide elements. The doublet term of Nd^{+++} is discussed in particular. For 4 to 7 *f* electrons Racah's theory is used [Abstr. 1618 (1950)], and Condon and Shortley's theory in simple cases. Tables of numerical results are given. Many references. C. TURNER

535.343

5316. Studies of absorption spectra. X. *d*-Electrons in crystal fields of different symmetries. C. J. BALLHAUSEN AND C. K. JØRGENSEN. *K. Danske Vidensk. Selsk., mat.-fys. Medd.*, **29,** *Paper* 14, 32 *pp.* (1955).

Group-theoretical derivation of the possible states in crystal fields of cubic, tetragonal and rhombic symmetry, presented as operations with simple 5-dimensional vectors. Behaviour of 1 to 5 *d*-electrons in these fields is discussed. A chapter on *d*-electrons in trigonal symmetry is given. C. TURNER

535.343 : 539.132

5317. The influence of vibration-rotation interaction on line intensities in vibration-rotation bands of diatomic molecules. R. HERMAN AND R. F. WALLIS. *J. chem. Phys.*, **23,** *No.* 4, 637–46 (*April*, 1955).

The influence of vibration-rotation interaction on line intensities in vibration-rotation bands of diatomic molecules had been recognized and treated approximately many years ago. In the present paper matrix elements have been calculated for the *P* and *R* branches of the 0–1, 0–2 and 1–2 transitions taking into account the interaction of rotation and vibration as well as the mechanical and electrical anharmonicity. For the 0–1 and 1–2 transitions the intensities of corresponding absorption lines in the *P* and *R* branches are proportional, in first-order approximation, to $[1 + 4\gamma\theta J]J$ and $[1 + 4\gamma\theta(J + 1)](J + 1)$, respectively, where J is the rotational quantum number of the initial state, $\gamma = 2Be/\omega_e$, $\theta = M_0/M_1 r_e$ and M_0 and M_1 are the first two coefficients in the electric dipole moment expansion about the equilibrium internuclear distance r_e. Corrections to the above expressions that are proportional to γ^2 have also been obtained. Formulae are given for the total integrated band intensity and for the line intensities summed over each branch taken individually. In the case of certain molecules, such as HCl for which $\theta \simeq 1$, it is possible to determine the magnitude of sign of θ by applying the above analysis to experimental data. For molecules such as CO, where $\theta \ll 1$, the effect is negligible for the fundamental transition. A semi-classical interpretation of the influence of vibration-rotation interaction on line intensity has also been given. A.

535.343

5318. Application of molecular beams to the radio spectroscopic study of the rotation spectra of molecules. N. G. BASOV AND A. M. PROKHOROV. *Zh. éksper. teor. Fiz.*, **27,** *No.* 4(10) 431–8 (1954) In Russian.

A detailed calculation of the effects obtainable when molecular beams replace static gas in microwave spectroscopy. With unsorted beams the advantage is a reduction of the Doppler width, down to 7 kc/s at 850°C for CsF for example. When the beams are sorted so that only one rotational state is present, emission of energy is possible and a molecular generator is obtained. Again with CsF for the $J_{1\to 0}$ transition with reasonable beam densities, Q factor of the cavity, etc., a signal-to-noise ratio of 7 is estimated. D. H. WHIFFEN

535.343 : 537.228.1 : 534.213

5319. On the piezoelectric lines at sub-microwave frequencies. S. KOJIMA, K. TSUKADA, S. OGAWA, A. SHIMAUCHI AND N. MATSUMIYA. *J. Phys. Soc. Japan*, **10,** *No.* 4, 265–9 (*April*, 1955).

Piezoelectric absorption lines which had been found in nuclear quadrupole resonance experiments were studied between 3 and 700 Mc/s. These lines were observed not only in powder, but also in single crystals. The present experiment showed that they were neither due to resonant vibrations of individual crystals in powder nor due to harmonics of the natural vibration of a single crystal. The absorption was dependent on crystal imperfection and related to very narrow regions in a crystal. The following mechanism was suggested: there are regions of smaller elastic-wave velocity within which vibrations are confined by total reflection at the boundary. A.

535.343 : 539.132 : 548.7

5320. Infrared spectrum and the structure of the low-temperature phases of crystalline HCl, HBr, and HI. D. F. HORNIG AND W. E. OSBERG. *J. chem. Phys.*, **23,** *No.* 4, 662–70 (*April*, 1955).

The infrared spectra of crystalline HCl, HBr and HI have been studied at −205°C. The fundamental

vibrations were observed in HCl at 2704 and 2746 cm^{-1}, in HBr at 2404 and 2438 cm^{-1} and in HI at 2120 cm^{-1}. In addition, low-frequency bands associated with torsional lattice vibrations were observed directly and in combination with the fundamental vibrations of the molecules. It is concluded that in the low-temperature crystalline phases both HCl and HBr form zigzag hydrogen-bonded chains, the angle between adjacent molecules being about 107° in HCl and 97° in HBr. The crystalline potential function is investigated for all three molecules. A.

535.343

5321. Interpretation of the near ultraviolet absorption spectrum of acetaldehyde molecule as due to a single electronic transition. V. Ramakrishna Rao and I. Achyuta Rao. *Indian J. Phys.*, **28**, *No.* 11, 491–510 (*Nov.*, 1954).

A complete analysis of the spectrum is obtained. About 113 bands are measured in the region λλ3485–2610 Å. The band at 3204·1 Å is chosen as the 0, 0 band. The C=O frequency is established to be 1125 cm^{-1} in the upper state instead of 1053 cm^{-1} as given by Eastwood and Snow (1935). The analysis shows the characteristics of an allowed transition. A.

535.343

5322. The polarized spectrum of anthracene. I. The assignment of the intense short wave-length system. D. P. Craig and P. C. Hobbins. *J. Chem. Soc.*, **1955**, 539–48 (*Feb.*).

Measurements have been made of the absorption spectrum of anthracene crystals between 2800 and 2300 Å, where absorption occurs related to the intense solution band system at 2500 Å. The molecular transition is assigned to the species A_g–B_{3u}, polarized parallel to the long axis. The interpretation of aromatic crystal spectra is discussed using Davydov's application of Frenkel's exciton theory, and the theory is then used to predict the main features of the crystal band systems corresponding to possible molecular transitions in anthracene. Comparison of these results with the measured spectrum shows that the intense system which has its maximum in solution at about 2500 Å is split in the crystal into two components. One, at 2700 Å, is polarized along the *b* monoclinic axis. The other, which is much more intense, is polarized in the *ac* plane and has its maximum at a wavelength less than 2340 Å, the limit of the measurements. The assignment to the species A_g–B_{3u} is based on (i) the much greater *ac* polarized absorption intensity than *b* polarized, (ii) the large Davydov splitting between oppositely polarized components and (iii) the displacement to short wavelengths of the mean crystal excitation energy relative to vapour and solution values. In all three there is good agreement between experiment and theoretical expectation for the proposed assignment. The results agree with the predictions of molecular orbital theory in both LCAO form and free-electron form. This will be discussed later, in conjunction with results on the long-wave system. A.

535.343

5323. Observed *n*-π* bands in the ultraviolet absorption solution spectra of amino asymmetric triazines. R. C. Hirt and R. G. Schmitt. Letter in *J. chem. Phys.*, **23**, *No.* 3, 600 (*March*, 1955).

The spectra of derivatives of 1, 2, 4 triazine were taken in order to investigate the effect of neighbouring N atoms on the position of the $n \rightarrow \pi^*$ transition. This band is obscured by the first $\pi \rightarrow \pi^*$ transition in 1, 3, 5 triazine. Both 3 amino-as-triazine and 2 amino-5, 6-dimethyl-as-triazine showed a clear $n \rightarrow \pi^*$ band, the latter at higher frequency, which is consistent with the blue shift caused by the methyl groups. Although both compounds contain amino groups which might cause a blue shift of the band, the neighbouring effect of the two conjugated N atoms is the stronger. A. J. Taylor

535.343

5324. Vapor absorption spectra of light and heavy naphthalenes at 2900–2500 Å. H. Sponer and C. D. Cooper. *J. chem. Phys.*, **23**, *No.* 4, 646–51 (*April*, 1955).

The 2900–2500 Å region of absorption in both light and heavy naphthalene is interpreted as an allowed A_{1g}–B_{2u} transition, and the bands at 35910 and 36040 cm^{-1} are assigned as the respective 0, 0 bands. Upper-state frequencies of 485, 710, 995, 1390, 1520 and 1600 cm^{-1} and the ground-state frequencies of 495, 755, 1024 and 1380 cm^{-1} in the ordinary naphthalene spectrum are correlated with previously reported Raman frequencies. A corresponding interpretation is given for the vibrational frequencies occurring in the spectrum of deuterated naphthalene. The general appearance of the spectrum is compared with recent absorption curves in solid solution by Passerini and Ross, and with crystal data obtained with polarized light. Possible occurrence of vibrationally induced "forbidden" bands is discussed. A.

535.343

5325. Intensities of vibration bands. VI. Alkyl esters. R. A. Russell and H. W. Thompson. *J. Chem. Soc.*, **1955**, 479–82 (*Feb.*).

For previous part, see Abstr. 7753 (1951). The intensities of the vibrational absorption bands of some esters near 1200 cm^{-1} have been determined, extending previous results of Francis. Most of the compounds give approximately the same value for this intensity, although methyl esters show a small but significant difference. The composite nature of the band is discussed and possible explanations suggested. The effect of different solvents upon the band intensity has been determined, and the values compared with that found in the gas phase. The results suggest that the Onsager relation for the intensity in the two phases is satisfactory. A.

535.343

5326. Intensities of vibration bands. VII. The NH group. R. A. Russell and H. W. Thompson. *J. Chem. Soc.*, **1955**, 483–6 (*Feb.*).

The integrated band areas of the fundamental stretching vibration band of the NH group in a number of types of compound have been determined, in order to correlate the band intensities with structural characteristics and the polar properties of this group. It has been found that marked differences occur

between compounds of different classes, and in particular the intensities are very low with dialkylamines. A.

535.343

5327. Intensities of vibration bands. VIII. The C≡N group. M. W. SKINNER AND H. W. THOMPSON. *J. Chem. Soc.*, **1955**, 487–9 (*Feb.*).

The intensity of the stretching vibration band of the C≡N group has been determined in a number of compounds by measuring the integrated band areas, using solutions in carbon tetrachloride. The vibration frequencies, half-band widths and extinction coefficients have also been determined. There are marked variations in the intensities which are related to structural features. A.

535.343 : 539.132

New radioelectric method for the study of the structure of matter in the solid phase. *See Abstr.* 5567

535.345

5328. The infra-red transmission of glass in the range room temperature to 1400°. F. J. GROVE AND P. E. JELLYMAN. *J. Soc. Glass. Technol.*, **39**, 3 T–15 T (*Feb.*, 1955).

In the investigation of the radiative heat flow in glass-melting tank furnaces, measurements of the infrared transmission of glass at high temperatures are required; such measurements also give information on the behaviour of colouring agents at high temperatures. In this paper the methods which have been used in making these measurements are discussed, and a new apparatus is described in which the sample is contained in a platinum cell with synthetic-sapphire windows. Results are reported for a number of iron-containing glasses and for a nickel glass at temperatures up to 1400°. In the case of iron-containing glasses, the changes in absorption, which take place with increase of temperature, suggest that the iron exists in a more highly oxidized state at high temperatures. Values are given for the "radiation conductivity"—the factor governing radiative heat transfer at high temperatures—for all the glasses measured, at 1200°. For the iron-containing glasses these values vary according to the iron content and the state of oxidation, the value for "Calorex" glass being about one-fifteenth of that for a low-iron glass. A.

535.345.6 : 535.41

5329. Direct monitor system for multilayer interference filters. V. L. LINDBERG AND M. J. IRLAND. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 328–9 (*April*, 1955).

A description is given of a photoelectric monitoring system for control of the thickness of the successive deposited layers in the production of multilayer reflecting films. Two photocells in opposition are used. This offers advantages over the single-cell method, the advantages being discussed. S. TOLANSKY

535.347 : 548.7

5330. Infrared dichroism and crystal structure. J.-P. MATHIEU. *J. Phys. Radium*, **16**, *No.* 3, 219–31 (*March*, 1955) In French.

Review, recapitulating theory of propagation of infrared in crystals, and approximate treatments. Critical account of recent experimental work using polarized light techniques on lattice vibrations, orientations of molecules and groups and deformations. 81 refs. J. HAWGOOD

535.371

5331. Decay of phosphorescence of long duration in magnesium oxide. B. D. SAKSENA AND L. M. PANT. Letter in *Curr. Sci.*, **23**, *No.* 12, 393–4 (*Dec.*, 1954).

535.371

5332. Some investigations on the effect of pressure on the luminescence of solids. I. E. A. BRAUN. *Bull. Res. Coun. Israel*, **4**, *No.* 3, 219–21 (*Dec.*, 1954).

ZnS activated by Ag or Cu showed no change in emission spectrum or intensity under ultraviolet when subjected to a pressure of 150 kg/cm² of O_2, but a small intensity loss was caused by a mechanical pressure of 500 kg/cm². The luminescence of X-ray film under ultraviolet at liquid air temperature decreased nearly linearly by 1% per 100 kg/cm² up to a pressure of 4000 kg/cm². Its sensitivity compared with ZnS is due to edge emission occurring at normal lattice sites. S. T. HENDERSON

535.371

5333. Some investigations on the effect of pressure on the luminescence of solids. II. E. A. BRAUN AND A. BAROUCH. *Bull. Res. Coun. Israel*, **4**, *No.* 3, 222–4 (*Dec.*, 1954).

Though sulphide phosphors show a large drop in efficiency after grinding, their glow curves are not greatly affected. ZnS–Ag showed a slight displacement of the main peak, while ZnCdS–Ag showed new peaks in the glow curve above 400°K. S. T. HENDERSON

535.371

5334. Action of iron on gold-activated zinc sulphides. N. ARPIARIAN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 11, 1202–5 (*March* 14, 1955) In French.

Optimum fluorescence in ZnS–Au phosphors is produced by $2{\cdot}2\times10^{-4}$ Au per g ZnS. Small concentrations of iron enhance the emission of ZnS–Au but larger amounts have a quenching effect. G. F. J. GARLICK

535.371

5335. Borazole and boron nitride scintillators. J. KIRKBRIDE. Letter in *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 253 (*April*, 1955).

535.371

5336. Apparatus for the measurement of the lifetime of phosphorescence phenomena. A. VAN ROGGEN AND R. A. VROOM. *J. sci. Instrum.*, **32**, *No.* 5, 180–3 (*May*, 1955).

The change of light intensity with time is compared with a variable exponential function on an oscilloscope. The constants of the exponential give the lifetime of the phosphorescent light. A.

535.371 : 532.77

5337. Fluorescent behavior of solutions containing more than one solvent. M. FURST AND H. KALLMANN. *J. chem. Phys.*, **23**, *No.* 4, 607–12 (*April*, 1955).

Fluorescent emission of organic solutions in combinations of solvents is investigated in order to determine the reasons for the suitability or unsuitability of solvents for high-energy induced fluorescence, particularly where these solvents do not influence the emission under ultraviolet irradiation. Basically two

types of behaviour under high-energy radiation are found in these combined solvent solutions. In type I a considerable drop in emitted intensity occurs only when the amount of the "poor" solvent greatly exceeds that of the "effective" solvent, whereas in type II small amounts of added "poor" solvent produce large decreases in emitted intensity. The fluorescence depends upon the concentration of solute, larger concentrations giving greater light outputs. The results obtained are explained by assuming that energy transfer occurs from the "poor" solvent to the "effective" one. At the same time a decrease in actual lifetime of excitation in the "effective" solvent occurs which is induced by the presence of the "poor" solvent molecules. This shows up as a quenching of the γ-ray induced fluorescence in solutions even with solutes which are scarcely quenched at all under ultraviolet light excitation. For type I behaviour this quenching is small while for type II it is considerable. A.

535.371.07

5338. Study of scintillation produced in a zinc sulphide screen by α-particles using a photomultiplier. J. P. ANTHONY. *J. Phys. Radium*, **16**, *No.* 3, 182–90 (*March*, 1955) In French.

535.372

5339. The vibration structure of the naphthalene fluorescence spectrum. II. Naphthalene in durol. H. C. WOLF. *Z. Naturforsch.*, **10a**, *No.* 3, 244–8 (1955) In German.

535.375.5

5340. A calculation of the limiting eigenfrequencies in the spectrum of mixed molecular crystals for various concentrations of the components. N. N. PORFOR'EVA. *Zh. éksper. teor. Fiz.*, **27**, *No.* 4(10) 439–44 (1954) In Russian.

These limiting frequencies are calculated for mixed isomorphic crystals of para-dibromobenzene and para-dichlorobenzene at concentration ratios of 1 : 1 and 1 : 3. Estimates of the force constants of the elastic interaction between molecules oscillating in phase are obtained by comparison of a theory based on previous work by Porfor'eva [Abstr. 1005 (1953)] with the results of experiments by Korshunov [Abstr. 5407–8 (1953)] and by Vuks. J. M. RADCLIFFE

535.376

5341. Cathodeluminescence study of (Ba, Sr)O. K. NOGA AND K. NAKAMURA. *Vide*, **9**, 113–15 (*July–Sept.*, 1954) In French and English.

Results of experiments in which the luminescent spectra of BaO, SrO and (Ba, Sr)O were obtained by bombardment of the specimen with electrons support the view that (Ba, Sr)O is a homogeneous solid solution [Abstr. 2404 (1946)] rather than the view of H. Kawamura (1941) that there are two separate phases of BaO and SrO. J. DUTTON

535.376

5342. Radiation controlled electroluminescence and light amplification in phosphor films. D. A. CUSANO. Letter in *Phys. Rev.*, **98**, *No.* 2, 546–7 (*April* 15, 1955).

A layer of ZnS–Mn–Cl phosphor is evaporated on to a glass surface with conducting TiO_2 coating and is then backed by a metal coating. Emission of luminescence due to u.v. or X-ray excitation is considerably enhanced by application of an electric field (10^5 V/cm) across the phosphor layer. The enhancement varies as the inverse square of excitation intensity. Ten visible photons can be obtained per photon of incident 3 650 Å radiation. G. F. J. GARLICK

535.376

5343. Theoretical basis for light-amplifying phosphors. F. E. WILLIAMS. Letter in *Phys. Rev.*, **98**, *No.* 2, 547–8 (*April* 15, 1955).

In the device of the preceding abstract u.v. excitation produces carriers (electrons) which are accelerated by the applied field to produce several excitations of emission centres by impact. Shift of 100 Å in the emission spectrum is due to strong perturbation of the Mn centres in the high fields (10^8 V/cm) of the exhaustion barriers formed. G. F. J. GARLICK

535.376

5344. Polarization effects on the brightness waves of electroluminescence. F. MATOSSI. *Phys. Rev.*, **98**, *No.* 2, 434–7 (*April* 15, 1955).

Electroluminescence excited by sinusoidal fields yields two maxima per half-period of the field. The intensity ratio of these maxima depends on field frequency and on the superposition of ultraviolet-excited luminescence. These observations are shown to be related to the existence of polarization effects, which are treated theoretically by extending previous theories of polarization effects in semiconductors (Jaffé and others), taking into account periodic excitations of centres by the field. A.

535.376 : 539.16.08

Possibility of a nuclear radiation detector by means of electroluminescent phosphors. *See Abstr.* 5596

535.377

5345. Determination of electron trap depths by thermoluminescence. G. CURIE AND D. CURIE. *J. Phys. Radium*, **16**, *No.* 3, 199–205 (*March*, 1955) In French.

A method of obtaining trap depths by varying the rate of warming in thermoluminescence is developed. Various other methods of finding trap depths are reviewed. G. F. J. GARLICK

535.377

5346. Experimental study of the mechanism of thermoluminescence in irradiated sodium chloride. J. J. HILL AND P. SCHWED. *J. chem. Phys.*, **23**, *No.* 4, 652–8 (*April*, 1955).

The general configuration of the emission spectrum of synthetic NaCl crystals which had been irradiated with $7 \times 10^5 r$ of X-rays at room temperature and were then permitted to luminesce at 500°K was determined; and bands were located with maxima at 362, 418, 432 and 525 millimicrons. The glow curves for NaCl crystals irradiated with X-rays or ultraviolet light were investigated, and eight bursts of light (glow peaks) were found with peaks at temperatures between 334 and 652°K. The relative contribution of the different bursts to the total glow curve was determined as a function of the amount of X-ray irradiation. The activation energies for five of the bursts were measured and in each case turned out to be about

1·25 eV. It is suggested that these results indicate that the thermoluminescence takes place by means of a two-stage process of the following sort. The first stage, which is the same for all the bursts and is thermally activated with the measured activation energy, takes place when trapped electrons are raised from *F*-centres into the conduction band. In the second stage, electrons in the conduction band fall into different empty energy levels, there being one type of level for each burst. The large observed differences between the peak temperatures of the different bursts is then due to large variations in the probabilities of this second process for different levels. A.

535.417

5347. On the resolving power of compound Fabry-Perot etalon. M. K. Machwe and M. S. Sodha. *Indian J. Phys.*, **28**, *No.* 11, 522–4 (*Nov.*, 1954).

The authors have calculated the resolving power of a compound Fabry–Perot etalon on both Rayleigh and Abbe criteria, taking into account the contribution of the tails of the individual intensity patterns of the two lines to the maxima of the resultant intensity pattern. A.

535.417

5348. Differential microinterferometer with polarized waves. M. G. Nomarski. *J. Phys. Radium*, **16**, *No.* 3, 9 S–13 S (*March*, 1955) In French.

A review of the principles of the differential interferometer. A set-up is described which makes use of two polarized beams for the production of interferograms. This is adapted to microscopic examination and an auto-compensating device is described for the microscopic study of surfaces. The polarized beams are secured by means of bi-prisms and the types of bi-prisms which can be used are discussed. The apparatus described has found application in crystallography, metallography and the metrology of thin films. S. TOLANSKY

535.55 : 537.228.3

5349. The piezo-optic and electro-optic properties of zinc blende [ZnS]. H. Poulet. Letter in *J. Phys. Radium*, **16**, *No.* 3, 237–8 (*March*, 1955) In French.

Examines the discrepancy between recent results [Abstr. 4438 (1954)] and those, previously overlooked, of Schramm [*Ann. Phys.* [*Leipzig*] **25**, 309 (1936)]. W. BARDSLEY

535.7

Physiological optics. Vision. *See under* "Medical science. Human physiology." Decimal classification 612.84

535.823.5

5350. A microscope hot stage using electron bombardment. G. J. Ogilvie and G. Brinson. *J. sci. Instrum.*, **32**, *No.* 5, 170–1 (*May*, 1955).

This is for use with metal specimens. The specimen is supported in a vacuum between three pointed wires, two of which are the elements of a thermocouple, and heated by electron bombardment. In this way very rapid heating of the specimen is possible with full control of temperature and with very small power inputs. A.

HEAT 536

536.2 : 536.3 : 537.39

5351. The distribution of temperature along a thin rod electrically heated *in vacuo*. VI. End-losses. S. C. Jain and K. S. Krishnan. *Proc. Roy. Soc. A*, **229**, 439–45 (*May* 24, 1955).

For Pt V, see Abstr. 1750 (1955). On the basis of the known distribution of temperature along a filament electrically heated *in vacuo*, the distributions of some of the other physical characteristics that are known functions of the temperature were investigated in Pt IV. By means of the expression thus obtained for the distribution of any given characteristic, the over-all performance of the filament for this particular purpose can be obtained by integration, and can be expressed in terms of a certain equivalent length of an ideal filament in which the loss by conduction at the ends is completely eliminated. The difference between the actual and the equivalent lengths, which is generally referred to as the correction for the end-losses, is calculated in the present part for some typical physical properties that are of practical interest. Among them are: (1) properties like the heat capacity, the heat generated and the total output of radiation, which are proportional to known powers of the temperature T; (2) properties like brightness and the rate of evaporation, which are proportional to known powers of $\exp(1/T)$; (3) properties like thermionic emission, which are proportional to known powers of T and of $\exp(1/T)$. The corrections for the end-losses thus calculated for a long filament of tungsten for the different properties are found to agree closely with those computed graphically by Worthing from the observed distributions of these properties along the filament. It is further shown that the correction for a filament of medium length, such as is used in high-frequency power-tubes, is practically the same as for a similar long filament heated by the same current. A.

536.21 : 518.5

5352. An analogue study of the temperature distribution in cooled gas-turbine blades. C. F. Kettleborough. *Brit. J. appl. Phys.*, **6**, *No.* 5, 174–6 (*May*, 1955).

An electrolytic tank analogue method is described. Numerical results agree very closely with those obtained by more laborious methods. A.

536.212.2 : 536.48

5353. The thermal conductivity of tin at low temperatures. S. J. Laredo. *Proc. Roy. Soc. A*, **229**, 473–92 (*May* 24, 1955).

An account is given of an accurate method of measuring the thermal conductivity of metals between 0·2 and 4°K using carbon aquadag resistance thermometers. Experimental curves are shown for tin specimens of different crystal structure and of varying impurity contents in both superconducting and normal states, and they are analysed on the basis of the two-fluid model of superconductivity. It appears that at low temperatures the conductivity is mainly due to the lattice, since the observed temperature variation for all specimens is consistent with a T^3 law at sufficiently

low temperatures. Good agreement is obtained between the effective mean free paths of the lattice waves and the values expected from the rod dimensions and crystal sizes. The electronic contribution to the thermal conduction in the superconducting state falls very rapidly below T_c, and, to a first approximation, the ratio of this contribution to that in the normal state is a function of temperature and not of impurity. The effects of magnetic fields on measurements of thermal conductivity are also briefly discussed and it is shown that the results may be complicated by frozen-in flux. A.

536.212.3 : 537.226.3 : 621.365.55

5354. Calculation of the temperature distribution in multi-layer materials subjected to high-frequency heating. A. V. Netushil. *Zh. tekh. Fiz.*, **24**, *No.* 6, 1035–40 (1954) In Russian.

The system considered consists of alternate layers of two dielectric materials (e.g. wood and glue), the layers having thickness b_1 and b_2, respectively. The materials have specific heats C_1 and C_2 and thermal conductivities λ_1 and λ_2, respectively. The system is placed between the plates of a heating condenser, the sources of heat produced by the applied electric field having densities w_1 and w_2, respectively. It is assumed that the losses of heat to the surroundings are negligible and that the system can be regarded as an infinitely long periodic structure. An expression for the difference between the temperatures, $\Delta\theta$, of the mid-planes of two adjacent layers is derived, showing that $\Delta\theta$ reaches a steady value in a comparatively short time after applying the electric field; further heating raises the temperature of the medium without affecting $\Delta\theta$. It is shown that for wood and glue $\Delta\theta$ reaches a steady value of 15°C after 2·5 sec.

R. S. SIDOROWICZ

536.212.3 : 548.7

The thermal conductivity of irradiated dielectric crystals at low temperature. *See Abstr.* 5725

536.24 : 539.172.4

5355. Liquid metal coolants. J. E. Terry and N. B. Skeats. *Atomic Energy Res. Establ.* [*Harwell*] *Inf. Bib.*, **94**, 18 *pp.* (1954).

A bibliography of 181 unclassified reports and literature references, up to mid-June (1954).

536.25 : 539.172.4

5356. Thermal convection in a long cell containing a heat generating fluid. W. Murgatroyd. *Atomic Energy Res. Establ.* [*Harwell*] *Rep.* E*D*/*R*1559, 16 *pp.* (1954).

Fully developed temperature and velocity profiles have been evaluated for laminar and turbulent flow in a long vertical cylindrical or parallel sided cell containing a heat generating fluid, and having isothermal walls. Values of the turbulent diffusivities have been taken from experimental results in forced convection channel flow. The reciprocal Nusselt Number has been plotted against Grashof Number. It is shown that in a highly rated nuclear reactor having a liquid metal fuel element, the heat transfer coefficient may be increased by about 60% by turbulence. If an aqueous solution is employed, turbulence can improve the heat transfer coefficient about twelve times. The effect of magneto-hydrodynamic forces on the flow in a model liquid metal cell using ohmic heating is briefly considered. It appears that a model cell could be built, using mercury, in which these effects are negligible. It does not appear possible to do this with a highly conducting liquid metal such as sodium. A.

536.413 : 548.7

5357. The lattice expansion of iron. Z. S. Basinski, W. Hume-Rothery and A. L. Sutton. *Proc. Roy. Soc. A*, **229**, 459–67 (*May* 24, 1955).

The lattice spacings of high-purity iron have been measured accurately between 20 and 1 502°C. The results, together with previous low-temperature data, give data between the absolute zero and the melting-point (1 534°C). The thermal expansion of the lattice and of bulk metal are in good agreement over the temperature range for which the latter has been studied accurately. At the A_2 point, there is no discontinuity in the lattice spacing. In contrast to the work of some previous investigators, no observable difference has been found between the coefficients of expansion of the lattice immediately above and below the A_2 point, and the results suggest that the forces responsible for ferromagnetism do not affect the interatomic distances by more than 1 part in 10 000. At the A_3 point, the $\alpha \rightarrow \gamma$ transformation is accompanied by an increase in the interatomic distance which, when expressed as a percentage change, is slightly less than the decrease in interatomic distance during the $\gamma \rightarrow \delta$ change at the A_4 point. The change in bond length calculated by the Pauling equation for the change (f.c.c. $\rightleftharpoons$ b.c.c.) lies between the observed values for the A_3 and A_4 points, and the accuracy of the equation is confirmed. A.

536.413.08 : 536.48

5358. A new method for measuring the thermal expansion of solids at low temperatures; the thermal expansion of copper and aluminium and the Grüneisen rule. D. Bijl and H. Pullan. *Physica*, **21**, *No.* 4, 285–98 (*April*, 1955).

The method is based on the measurement of the change of capacity of a condenser produced by a change in length of the specimen. Experimental results on the thermal expansion of copper and aluminium are discussed in relation with Grüneisen's rule. This rule is shown to break down at temperatures below about $0{\cdot}3\theta$, the expansion becoming smaller than the values predicted by Grüneisen's rule. This deviation can be explained in terms of Born–Von Karman's lattice dynamics. A.

536.42

5359. Germanium-oxygen system. E. S. Candidus and D. Tuomi. Letter in *J. chem. Phys.*, **23**, *No.* 3, 588 (*March*, 1955).

The germanium-oxygen phase diagram was established by heating Ge–GeO_2 mixtures to 800–960°C and cooling to room temperature. The phase diagram was then found by X-ray diffraction and microscopic characterization of the products formed. Below 870°C the phases consisted of Ge and hexagonal GeO_2; from 870 to 940°C there are two liquid phases. The eutectic temperature was found to be 870°C. The effect of oxygen on the germanium melting point was also studied. A. J. TAYLOR

536.421.1 : 539.42 : 548

5360. Theory of melting and yield strengths. H. Aroeste. Letter in *Phys. Rev.*, **97**, *No.* 6, 1723–4 (*March* 15, 1955).

An estimate of the yield strength of single crystals in terms of the latent heat of melting gives values which are too high by a factor of 10. R. O. DAVIES

536.421.4

5361. A study of the thermal diffusion equation with boundary conditions corresponding to solidification or melting of materials initially at the fusion temperature. F. Kreith and F. E. Romie. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 5, 277–91 (*May*, 1955).

Solutions are presented for determining the position of the solid-liquid interface and the temperature-time history of the surface of solidifying of melting materials initially at the fusion temperature. These solutions include treatment of the cylinder, the sphere and the semi-infinite solid. Solutions were obtained by analytical methods and by means of an electrical analogy to the thermal system. The application of the electrical analogy to the solution of problems in solidification is described. A.

536.423.15

5362. The vapor pressure of americium metal. S. C. Carniglia and B. B. Cunningham. Note in *J. Amer. Chem. Soc.*, **77**, *No.* 6, 1502 (*March* 20, 1955).

536.48 : 539.11 : 539.21 : 548.7

5363. The properties of solid argon. C. Domb. *Nature* [*London*] **175**, 661–3 (*April* 16, 1955).

Brief report of a meeting of the Low Temperature Group of the Physical Society, held on Feb. 8.

536.48 : 621.317.32.027.21 : 621.316.543.1

5364. A superconducting reversing switch. I. M. Templeton. *J. sci. Instrum.*, **32**, *No.* 5, 172–3 (*May*, 1955).

The measurement of small voltages in a liquid helium bath is often seriously complicated by the existence of relatively large thermal voltages developed in the leads brought out to the measuring apparatus (e.g. potentiometer) at room temperature. A superconducting modulator has already been developed by the author for measuring voltages $<10^{-6}$–10^{-7} V, but this is unnecessarily complicated for the higher ranges. For voltages of 1μV and upwards, the required accuracy may readily be attained using conventional instruments if a reversing switch can be provided in the liquid helium bath, so that "spurious" e.m.f.'s may be eliminated. Such a switch is described in which either of two pairs of tantalum wire elements may be brought into the normal (resistive) state by energizing miniature electromagnetic circuits. Some measurements of small thermal electromotive forces illustrate the performance of the switch. A.

536.48

5365. Slope of the λ curve of liquid helium. K. R. Atkins. *Phys. Rev.*, **98**, *No.* 2, 319–20 (*April* 15, 1955).

Landau's theory of liquid helium is developed to give an approximate value of the slope of the λ-curve in terms of the quantities $(\rho/\Delta)\partial\Delta/\partial\rho$, $(\rho/p_0)\partial p_0/\partial\rho$ and $(\rho/\mu)\partial\mu/\partial\rho$. From the experimental data on the coefficient of expansion and the pressure variation of the velocities of first and second sound, the following numerical values are derived for these quantities: $(\rho/\Delta)\partial\Delta/\partial\rho = -0{\cdot}57$, $(\rho/p_0)\partial p_0/\partial\rho = +0{\cdot}26$, $(\rho/\mu)\partial\mu/\partial\rho = -1{\cdot}8$. The negative slope of the λ-curve can then be explained and its magnitude predicted with an accuracy of about 15%. A.

536.48

5366. Further experiments on mutual friction in liquid helium II. P. Winkel, A. M. G. Delsing and C. J. Gorter. *Physica*, **21**, *No.* 4, 312–21 (*April*, 1955).

Further experiments [see Abstr. 2416 (1953)] were carried out on the flow of liquid helium II in an annular flat slit, with a length of 0·134 cm. The slit width varied between 0·4–6μ. The frictional force F, defined as the difference between the observed and theoretical fountain effect, was studied in its dependence on the (relative) velocity v. It was found to vary with a power of this velocity, which in most cases was not very different from three. Comparison of the absolute values of the frictional forces with those obtained earlier in a longer slit (0·434 cm) indicates that the forces are roughly proportional to the slit length. This result suggests that the friction phenomena do occur in the whole slit and not only at the (narrowest) entrance. A.

536.48

5367. Some calculations with the two-fluid model, concerning the flow of liquid helium II. P. Winkel. *Physica*, **21**, *No.* 4, 322–30 (*April*, 1955).

The calculations concern the flow in an apparatus consisting of two volumes connected by a slit or capillary. In such an apparatus the difference in level (ΔH) and temperature (ΔT) can vary as a result of a heat input in one of the volumes. The behaviour of ΔH and ΔT as a function of time is calculated on the basis of the equations of motion of the two fluids and the principle of conservation of energy. Details of the results obtained are discussed, some of which turned out to be independent of the existence of a critical velocity or even a mutual friction force. The relation between this mutual friction force and the amount of liquid flowing after the heat supply has been stopped (the "overshoot") was also calculated. A.

536.48

5368. On the existence of critical velocities in liquid helium II. P. Winkel, A. M. G. Delsing and J. D. Poll. *Physica*, **21**, *No.* 4, 331–44 (*April*, 1955).

The friction forces occurring in liquid helium II are studied, especially at low velocities, in order to obtain information about the possible existence of a critical velocity. It is concluded that such a critical velocity indeed appears to occur. The formalism given in another paper (preceding abstract) was tested and confirmed by the data obtained. A.

536.48

5369. Some vibrational properties of solid helium. D. J. Hooton. *Phil. Mag.*, **46**, 485–98 (*May*, 1955).

A series of experimental measurements on the specific heat and other vibrational properties of solid

helium [Dugdale and Simon, Abstr. 6725 (1953)] are here given a theoretical basis in terms of a new form of harmonic lattice dynamics, due originally to Born, and further developed by the author. The relative magnitude of the zero-point energy in solid helium is such that the customary lattice dynamics, which takes no account of the anharmonic terms in the actual lattice motion, breaks down (the proper frequencies becoming negative); the new theory provides a harmonic approximation with frequencies anharmonically defined, and can be used over the full range of molar volumes which can be achieved in solid helium. The results are expressed in terms of a Debye approximation with characteristic temperature θ; this θ differs in absolute value from the purely empirical Debye-type parameter introduced by Dugdale and Simon, but otherwise has similar properties. The significance according to this theory of the Grüneisen equation of state found by these authors is fully discussed. Some vibrational properties on the melting curve, treated by C. Domb, are reconsidered from a properly anharmonic point of view. A.

536.48

5370. On the hydrodynamics of He II in the phonon region. A. Morita. *Sci. Rep. Tôhoku Univ. First Ser.*, **38**, *No.* 1, 20–30 (*June*, 1954).

From the equations of hydrodynamics given by Irving and Kirkwood by means of the statistical mechanics, the equations of hydrodynamics which contain explicitly the quantities concerning both phonons and macroscopic fluid flows are derived. The technique dividing the total space occupied by the fluid into cells with such a dimension that macroscopic fluid flows can be considered to be almost constant within it is used, and the results obtained classical-mechanically in such cells is reinterpreted quantum-mechanically. It is shown that the equations of hydrodynamics of phonon gas can be separated from these equations under some assumptions. The results are applied to He II in the very low temperature region, where phonon effects are predominant. The mean free path of phonons is discussed. A.

536.48

5371. Helium II film transport. I. The role of substrate. B. Smith and H. A. Boorse. *Phys. Rev.*, **98**, *No.* 2, 328–36 (*April* 15, 1955).

Liquid helium II film transport from aluminium, silver, copper, nickel, nickel-silver, stainless steel, Pyrex, quartz and Lucite beakers has been measured using a variation of a previously described electrical technique. The degree of reproducibility and background variation observed in separate experiments on the same or on similarly prepared specimens of the same material was studied in detail. Rates on machined metals were found to be considerably lower than would be expected from many previous reports. In fact, rates measured over all the aforementioned materials were so similar in magnitude and reproducibility that the background variations involved prevent the resolution of any systematic dependence on substrate material which might exist. This is consistent with the size of the helium-substrate interaction as calculated by Schiff for copper, silver and glass. A.

536.48

5372. Second sound in superfluid He^3-He^4 mixtures. C. Horie. *Sci. Rep. Tôhoku Univ. First Ser.*, **37**, *No.* 4, 349–55 (*Dec.*, 1953).

Attempts to obtain an expression for the velocity of second sound in He^3–He^4 mixtures. It appears that on one assumption He^3 oscillates nearly in the same amplitude and phase as the He^4 normal component. A.

536.521

5373. A glass surface temperature pyrometer. J. R. Beattie. *J. Soc. Glass Technol.*, **38**, 457–69 (*Oct.*, 1954).

A pyrometer is described which has been developed for the measurement of the surface temperature of glass. The temperature range covered is 150–550°. The theory underlying the design of the pyrometer, which is sensitive over a selected band of wavelengths in the infrared, is outlined, and the errors which may be encountered in practice are discussed. A.

536.521

5374. An infra-red radiation pyrometer. J. D. Harmer and B. N. Watts. *J. sci. Instrum.*, **32**, *No.* 5, 167–70 (*May*, 1955).

The construction of a general purpose radiation pyrometer using a lead sulphide photocell is described. Based on a comparison principle, the instrument is independent of ambient temperature variations. The temperature range covered is 200–1 000°C with an accuracy of ±5 deg. C and a response time of less than 0·1 sec. A.

536.531

5375. Thermistor electronic thermometer. R. W. Woods. *Science*, **121**, 337–8 (*March* 4, 1955).

Continuous measurements of rectal, subcutaneous and skin-surface temperatures of mice were made with thermistors in bridge circuits. Nineteen such circuits were connected to a bank rotary switch so that any temperature could be selected and measured on a valve voltmeter. The range was 0–50°C and the sensitivity about 1%. E. H. DOCK

536.581

5376. A thermostat to replace low-temperature slush baths. C. Taylor. *Appl. sci. Res. B*, **4**, *No.* 4, 271–7 (1955).

A simple thermostat for the range of temperatures down to −170°C is described. It fits inside a 1 litre Dewar flask and is intended as an aid in handling volatile substances in vacuum systems. A.

536.62

5377. General theory of Calvet's microcalorimeter. G. Laville. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1060–2 (*March* 7, 1955) In French.

The equations governing the flow of heat between the various parts of the calorimeter, and their temperatures, are stated and solved using the Laplace transformation and orthogonal functions. S. WEINTROUB

536.62

5378. Semi-micro calorimeter. E. Hutchinson and K. E. Manchester. *Rev. sci. Instrum.*, **26**, *No.* 4, 364–7 (*April*, 1955).

To facilitate heats of wetting measurements, a metal calorimeter has been designed and constructed which

employs a platinum resistance thermometer for temperature measurement and an evacuated dead space to minimize heat losses. Auxiliary circuits for the temperature bridge, and bath temperature control are shown. Initial measurements of the heats of solution of NaCl, both coarse and finely divided samples, indicate a precision of measurement of 0·08%. The surface energy of NaCl, calculated from these data, is 366 ergs/cm^2. A.

536.62

5379. A 27°C isothermal calorimeter. P. A. Giguère, B. G. Morissette and A. W. Olmos. *Canad. J. Chem.*, **33**, *No.* 4, 657–64 (*April*, 1955).

The need for a Bunsen-type isothermal calorimeter operating as close as possible to the standard thermochemical reference temperature, 25°C, was fulfilled by means of diphenyl ether (m.pt. 26·9°C) as the working substance. The instrument was calibrated electrically by comparison with the ice calorimeter and the constant was found to be 19·01 ± 0·02 cal per g of mercury. From this and other known properties of diphenyl ether the density of the solid at the melting point was estimated at 1·188 g per ml. Check determinations based on the heat of vaporization of water showed that for such measurements the mantle of solid ether must first be melted inside by an amount equivalent to the heat to be measured. The calorimeter was operated in a large water-thermostat kept constant to within 0·001°C. With highly purified diphenyl ether there was no noticeable temperature drift during the measurements. Quantities of heat up to 600 cal could be measured with a reproducibility of the order of 0·2%. The new calorimeter is simpler to operate than the ice calorimeter and its sensitivity is more than three times as great. A.

536.626.2 : 536.662

5380. A new high precision calorimeter for the measurement of heats of combustion: and the heat of combustion of succinic acid. G. Pilcher and L. E. Sutton. *Phil. Trans A*, **248**, *No.* 938, 23–44 (1955).

The construction, calibration and use of a high-precision bomb calorimeter of the aneroid type are described. It consists of a stainless-steel combustion bomb as designed by Carlton-Sutton (1933) in a mantle of aluminium alloy, the temperature of which is measured by a platinum-resistance thermometer. A simple means of measuring the electrical ignition energy has been devised. Because the time required for the attainment of a thermal steady state is greater for this type than for the conventional water calorimeter, the theory underlying methods of allowing for heat loss from the calorimeter to its surroundings has been critically re-examined, and the limitations of the commonly used Dickinson method (1914) have been clearly stated. For high precision to be attained, it proves to be particularly necessary that the conditions under which calibrations and measurements are performed shall be as similar as possible. Working under optimum conditions, chosen after systematic trials, it is possible to reduce to 0·012% the standard deviation of the values for the calibration constant, with benzoic acid as the standard substance. The heat of combustion of succinic acid has been redetermined as $-\Delta U_R = 3020{\cdot}57 \pm 0{\cdot}43$ cal/g (vac.). This agrees very well with the high-precision determination by Huffmann (1938) 3020·47 ± 0·43. Succinic acid is suitable as a secondary standard for combustion calorimetry; and the best value is taken to be 3020·5 ± 0·5 cal/g (vac.). A.

536.631 : 536.48

5381. The low-temperature specific heats of vitreous and crystalline silica. M. Dank and S. W. Barber. Letter in *J. chem. Phys.*, **23**, *No.* 3, 597–8 (*March*, 1955).

Measurement on these can be fitted between 5°K and 30°K by a modification of an expression due to Tarassov which contains the Debye function $C_3(\theta_3/T)$ as well as $C_2(\theta_2/T)$ and $C_2(\theta_3/T)$ with $\theta_n = h\nu_n/k$. $C_2(\theta_n/T)$, representing the heat capacities of two-dimensional continua, is to be tabulated and analysed shortly. ν_2 can be calculated from the temperature dependence of the specific heats of vitreous silica, but in order to obtain experimental fit the large mass unit of Si_3O_6 must be used. The calculated value for ν_2 is close to the infrared frequency of 116 cm^{-1} observed at room temperature. Data on cristobalite can be treated similarly. This suggests the existence at low temperatures of highly anisotropic structures for cristobalite and vitreous silica contrary to the views based on X-ray studies. The anisotropy implied seems to require a more extensive lattice order, greater than 8 Å, in accordance with light scattering and electron microscopy experiments. The heat capacity data for quartz reveal no evidence of molecular-scale anisotropy. E. W. KELLERMANN

536.66

5382. The variation of the heat of mixing with temperature. G. H. Cheesman and W. R. Ladner. *Proc. Roy. Soc. A*, **229**, 387–95 (*May* 10, 1955).

A calorimeter designed for the determination of heats of mixing of small quantities, about 5 cm^3, of liquids without any vapour phase has been modified so as to make possible measurements over a much wider temperature range. Heats of mixing of the equimolar mixtures benzene ± toluene, toluene + *para*-xylene and benzene + *para*-xylene have been measured over the temperature range 5 to 65°C. A.

THERMODYNAMICS 536.7/.8

536.7

5383. Criticism of the expressions of the second law of thermodynamics. S. Fujita. *Kumamoto J. Sci. A*, **1**, *No.* 4, 31–9 (*March*, 1954).

536.7

5384. Fluctuations in non-equilibrium stationary systems. I. Prigogine and G. Mayer. *Bull. Acad. Roy. Belgique Cl. Sci.*, **41**, *No.* 1, 22–9 (1955) In French.

The probability of the occurrence of fluctuations around non-equilibrium stationary states is discussed. It is related to deviations from the theorem of minimum entropy production. It is shown that the use of classical Einstein fluctuations formula is justified as long as the theorem of minimum entropy production

is valid. A simple example, the fluctuation of the thermomolecular pressure, is considered in some detail. A.

536.7

5385. The principle of Carathéodory. R. EISENSCHITZ. *Sci. Progr.*, **43**, 246–60 (*April*, 1955).

The second law of thermodynamics is deduced from experimental facts, without considering cycles and avoiding the use of cumbersome mathematics.

R. EISENSCHITZ

536.71 : 539.32 : 539.11

Equation of state of crystalline argon. *See Abstr.* 5548

ELECTRICITY 537

537.1

5386. The échelon unit, the impulse unit and the Dirac operator. R. CAZENAVE. *Ann. Télécomm.*, **10**, *No.* 3, 50–3 (*March*, 1955) In French.

This paper is concerned with discontinuities in various electric phenomena. The mathematics is related to Schwartz theory of distributions. The concept of the impulse unit is introduced and it is reduced to the generalized derivative of the échelon unit. This in turn is connected with the Dirac function. L. S. GODDARD

ELECTROSTATICS . DIELECTRICS 537.2

537.212

5387. A rubber-membrane model for axially-symmetric electric fields. B. J. MAYO. Note in *Brit. J. appl. Phys.*, **6**, *No.* 4, 141–2 (*April*, 1955).

It is suggested that the rubber-membrane model can be applied to axially symmetric field systems, with or without space charge, by applying pressure by means of pads to the under side of the membrane.

J. HUGHES

537.226.1

5388. The locus of the complex molar polarization of a polar dielectric in the dispersion range. B. EKELUND. *Åbo: Åbo Akademi* (1955) 9 *pp. Meddelanden från Åbo Akademis Fysikaliska Institut No.* 39 [*Acta Academiae Aboensis Mathematica et Physica XX*, 2].

Deals with the utilization of the Argand diagram for the complex molar polarization in the treatment of dielectric polarization in the dispersion range. The diagram corresponds to that introduced by Cole and Cole for the representation of the complex dielectric constant. As an illustration of the application of the method, it is shown how the method of Potapenko and Wheeler for the determination of the dipole moment of a polar compound can be modified to yield more correct results. A.

537.226.2

5389. The dielectric constant of polar liquids at high field strengths. F. BOOTH. *J. chem. Phys.*, **23**, *No.* 3, 453–7 (*March*, 1955).

A critical examination is given of a simplifying assumption made in an earlier calculation [Abstr. 4366 (1951); 272, 1766 (1952)] of the functional dependence of the integral dielectric constant of polar liquids on the applied field. It was assumed in this calculation that, for the cavity and reaction fields at all field strengths the usual expressions for low field strengths could be employed. It was pointed out that this simplification is plausible if the static dielectric constant is large compared with the optical dielectric constant. In the present note it is shown that, if it is postulated that the reaction field alone retains its conventional value, then the cavity field is appreciably increased by dielectric saturation. In the case of water the effect is equivalent to an increase of the external field by about 10%; a modified relation between the field and the dielectric constant is suggested. The alteration of the reaction field as a result of saturation, and the effect of this modification on the dielectric constant, are also examined. A.

537.226.2

5390. Temperature dependence of the dielectric constant of diamond. P. T. NARASIMHAN. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 5, 315–18 (*May*, 1955).

This was measured over the temperature range 50–200°C. The value of $\varepsilon^{-1}d\varepsilon/dT$ over this range is $+1\times10^{-5}$. Details of the method of measuring the temperature coefficient of dielectric constant are also given. The magnitude and sign of $\varepsilon^{-1}d\varepsilon/dT$ for diamond has been theoretically calculated using Maxwell's relationship and Kramers–Heisenberg theory. The agreement between theoretical and experimental values is extremely good. A.

537.226.2 : 548.7

5391. The optical and electrical properties of single crystals of sodium niobate. L. E. CROSS AND B. J. NICHOLSON. *Phil. Mag.*, **46**, 453–66 (*May*, 1955).

The optical strains and dielectric constants of small single crystals of sodium niobate have been measured over the temperature range −190°C to +650°C. At room temperature the properties are consistent with an antiferroelectric structure, and for high fields applied perpendicular to the orthorhombic *c* axis, double hysteresis curves have been observed. At low temperature there is evidence of ferroelectric properties for fields applied parallel to the *c* axis. In the most perfect crystals the Curie temperature is below −209°C, but the ferroelectric phase may be induced by a high electric field. There is a long thermal hysteresis on this change and once transformed the crystals remain ferroelectric to −55°C. Above 350°C the symmetry is only pseudo-tetragonal, truly orthorhombic, and two minor structure changes, at 470°C and 518°C are observed, before the structure becomes cubic at 638°C. A.

537.226.2 : 621.315.612.4 : 621.319.1

5392. Ferroelectricity. R. C. VERNON. *Amer. J. Phys.*, **23**, *No.* 4, 183–91 (*April*, 1955).

A general description of the phenomena is given together with a brief history, and ferroelectricity and ferromagnetism are compared. The properties of the three main types of ferroelectrics, the barium-titanate,

KDP (potassium dihydrogen phosphate), and Rochelle-salt types, are discussed in relation to their crystal structures. A.

537.226.2

5393. Solid-state reactions and dielectric properties in the system magnesia–lime–tin oxide–titania. L. W. Coughanour, R. S. Roth, S. Marzullo and F. E. Sennett. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 3, 149–62 (*March*, 1955).

A study has been made of solid-state reactions in the quaternary system $MgO–CaO–SnO_2–TiO_2$ and in its subordinate binary and ternary systems. Compatibility relations have been determined for each. Extensive solid-solution formation has been noted in the $SnO_2–TiO_2$, $MgO–SnO_2–TiO_2$, $CaO–SnO_2–TiO_2$ and $MgO–CaO–SnO_2–TiO_2$ systems. Little or no solid solution was observed in the other systems involved. One ternary compound, having the probable formula $2MgO.SnO_2.TiO_2$, has been observed. No quaternary compounds were detected. A survey has been conducted of the effect of composition and temperature variations on the dielectric properties of specimens in some of these systems. Data are given for the values of K and Q at 50 kc/s, and at 1 and 20 Mc/s. The changes in these values with changes in temperature have been studied at 1 Mc/s. Indexed X-ray powder patterns are listed for the compounds $CaO.TiO_2$, $CaO.SnO_2$ and $2MgO.SnO_2.TiO_2$. An unindexed pattern is given for the compound $2CaO.SnO_2$. A.

537.226.2 : 548.574

Etch patterns and domains of $BaTiO_3$ crystals. *See Abstr.* 5706

537.226.2 : 621.319.4 : 621.315.61

5394. Some measurements on non-linear dielectrics. M. D. K. Minkiewicz and H. le Caine. *Nat. Res. Coun. Canada Publ., No.* 3152, 4 *pp.* (1954).

The non-linear dielectric material employed in a number of small-size ceramic capacitors was investigated, with particular regard to h.f. The position of the Curie point suggests that the composition of these capacitors is ~72% $BaTiO_3$ and 28% $SrTiO_3$. A typical coupling capacitor of 0·01 μF capacitance has an initial permittivity of 6000. When a 450 V d.c. is applied, the capacitance drops to $\frac{1}{3}$ of the value with no d.c. voltage applied. Standard ceramic capacitors, as supplied for circuit components, are therefore suitable for all the applications to which non-linear dielectrics may be put. These applications include control of oscillator frequency by a voltage, control of phase shift by a voltage, control of the cut-off frequency of a high-pass or low-pass filter by a voltage, remote circuit tuning, and use in dielectric amplifiers, high-sensitivity thermostats, and so forth. The extreme capacitance change is >10·1, but the region of high sensitivity to polarizing voltage extends over a range of 3 : 1. Measurements were made up to a frequency of 160 Mc/s. Up to this limit no evidence was found of a decrease in non-linearity with frequency. Since the only titania dielectrics which exhibit non-linearity have very high permittivity—6000 being a representative figure—it will be very difficult to use the non-linear properties of these dielectrics at v.h.f. A.

537.226.8 : 621.317.333.6 : 621.315.615

5395. Dependence of the electric strengths of liquids on electrode spacing. A. H. Sharbaugh, J. K. Bragg and R. W. Crowe. *J. appl. Phys.*, **26**, *No.* 4, 434–7 (*April*, 1955).

Using a reproducible pulsed voltage technique, the electric strengths of liquid hexane, heptane and tetradecane have been measured with small electrode spacings (approximately 2 to 200 microns). The electric strengths are found to change inversely with the logarithm of the separation in accord with theoretical expectation. On the basis of an approximate model of the breakdown process, the measurements on heptane yield values of 9×10^{-7} cm for the electron mean free path in the liquid and 9 for the number of multiplications per electron required for breakdown. A.

537.228 : 539.216

5396. The orientation of fibres in an electric field. J. O. Isard. *Brit. J. appl. Phys.*, **6**, *No.* 5, 176–9 (*May*, 1955).

Fibres dispersed in a liquid are observed to turn into the direction of an applied electric field. The effect is attributed to a difference of conductivity between fibre and liquid or when both conductivities are very low, to a difference of dielectric constant. It is suggested that the effect might be used in microscopic examination of textiles. A.

537.228.1

5397. On the measurement of the piezoelectric constant of $BaTiO_3$ ceramic. P. Buriánková. *Slaboproudý Obzor*, **15**, *No.* 12, 574–8 (1954) In Czech.

Several static and dynamic methods of measuring the piezoelectric constant, d, are briefly described and compared, the method based on the resonant curve being treated in detail. An expression is derived, for a thin piezoelectric slab with two parallel electrodes, giving d in terms of the resonant and anti-resonant frequencies, length, density and dielectric constant of the material. The equivalent inductance, capacitance and resistance of the slab are evaluated. The resonant-curve method of measurement is based on the superheterodyne principle, the value of d obtained from the measurement on a sample composed of $BaTiO_3$ + 4% $PbTiO_3$ being in agreement with the figures reported by other authors. R. S. Sidorowicz

537.228.1 : 534.213 : 535.343

Piezoelectric resonances at sub-microwave frequencies. *See Abstr.* 5319

537.228.1 : 534.23

5398. The effect of temperature and acoustic impedance of vapours on the electrical constants of quartz. S. Parthasarathy and V. Narasimhan. *Ann. Phys. [Leipzig]* **15**, *No.* 5–6, 302–10 (1955).

The equivalent resistance of a piezoelectric quartz crystal vibrating in various vapours of organic liquids at various temperatures was measured and the results compared with the values indicated by theory. It is found that the equivalent resistance at a given temperature depends on the pressure; its variation with temperature is linear and decreases with increasing temperature. A.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.31

5399. On diffusion in an external field and the adjoint source problem. J. KEILSON. *Quart. appl. Math.*, **12**, *No.* 4, 435–8 (*Jan.*, 1955).

If diffusion in an external field is described by $\partial\rho/\partial t = D\nabla^2\rho - \rho/\tau - \nabla . [\mathbf{F}(\mathbf{r})\rho]$, the function $\gamma(r_0)$ describing the probability that a particle at r_0 will reach a collector surface before decaying or being absorbed by other surfaces satisfies the equation $D\nabla^2\gamma - \gamma/\tau + \mathbf{F}(\mathbf{r}).\nabla\gamma = 0$. This equation has no singularity to disturb any geometric symmetry available. Boundary conditions on $\gamma(r)$ at the collector surface and other influencing surfaces are derived and shown to be independent of the external field. The boundary conditions at the secondary surfaces are homogeneous. The collector surface boundary condition is inhomogeneous. A.

537.311.31 : 539.234

5400. The resistivity of thin metallic films. D. E. CLARK. *Brit. J. appl. Phys.*, **6**, *No.* 5, 158–60 (*May*, 1955).

The resistivities of thin films of antimony and of bismuth were measured by direct current and at frequencies of $0{\cdot}92\times10^{10}$ c/s and $2{\cdot}65\times10^{10}$ c/s. For bismuth films the resistivity measured by microwaves was found to be about 0·8 times that measured by direct current. For antimony films there appears to be no systematic difference between these values. A.

537.311.31 : 548.7

5401. Orientation and temperature effects on the electrical resistivity of high-purity magnesium. J. L. NICHOLS. *J. appl. Phys.*, **26**, *No.* 4, 470–2 (*April*, 1955).

The effect of crystal orientation on the electrical resistivity of high-purity magnesium at 24°c may be represented by the equation $\rho(\phi) = 4{\cdot}60 - 0{\cdot}75\cos^2\phi$ (in microhm/cm³), where ϕ is the angle between the hexagonal axis and the direction of current flow. The effect of temperature on the electrical resistivity for varying orientations shows temperature coefficients of 0·003 90 and 0·004 08/°c obtained perpendicular and parallel to the hexagonal axis, respectively, for the temperature range of 24 to 200°c. Magnesium shows rotational symmetry about the hexagonal axis with respect to electrical resistivity. Grain size has little or no effect on the electrical resistivity of magnesium. A.

537.311.33 : 621.385.032.216

5402. The nature of the donors in the interior of oxide layers. Calculation of their dissociation energy. J. ORTUSI. *Vide*, **9**, 100–5 (*July–Sept.*, 1954) In French.

Concludes with the following model. (1) Before activation: ionic semiconductor with Schottky defects and intrinsic conductivity. (2) After activation: mixed semiconductor with 2 groups of donors, one consisting of *F*-centres, with a barrier of 2·3 eV in considerable concentration; the other, consisting of masses of colloidal Ba, barrier 1·4 eV, similar to that encountered in the theory of the photographic image; owing to the lower energy barrier the latter mechanism constitutes the major contribution to the conductivity. In mixed oxides the colloidal Ba plays the major rôle but the conductivity of SrO and CaO depends only on the *F*-centres. A. H. W. BECK

537.311.33

5403. Diamagnetic resonance in electronic conductors. R. B. DINGLE. Letter in *Phys. Rev.*, **98**, *No.* 2, 550 (*April* 15, 1955).

See Abstr. 3693, 7404 (1952); 2432 (1954); 1814 (1955). The author claims priority for theoretical treatment.

537.311.33 : 537.32

5404. On the thermoelectric properties of the impurity semiconductors. E. LAURILA. *Ann. Acad. Sci. Fennicae AI*, *No.* 178, 11 *pp.* (1955).

The formulae for Seebeck, Peltier and Thomson coefficients for impurity semiconductors are derived on the basis of the statistical theory of conductivity. As an example the theory is applied to a germanium *pn*-junction. For the thermoelectric power at room temperature the value of about 2 mV per degree is obtained. A.

537.311.33

5405. Injected current carrier transport in a semi-infinite semiconductor and the determination of life-times and surface recombination velocities. W. VAN ROOSBROECK. *J. appl. Phys.*, **26**, *No.* 4, 380–92 (*April*, 1955).

With both surface and volume recombination taken into account, time-dependent and steady-state Green's functions are obtained for a point source of added carriers in a semi-infinite semiconductor, and for infinite line and plane sources parallel to the surface. Small-signal theory is employed, and a compact Stieltjes-integral derivation is given. The Green's functions are specialized to provide: the time dependence of surface concentration following the instantaneous injection of carriers at a point on the surface; that following instantaneous injection which is uniform over the surface; and the distance dependences for steady point, infinite-line, semi-infinite plane and semi-infinite line surface sources. Steady flows of minority carriers from these sources into a *p–n* junction perpendicular to the surface are also calculated. Analytical approximations are found for the steady-source cases. Theoretical and experimental aspects of the determination of lifetimes and surface recombination velocities from data by means of these results are discussed. A.

537.311.33

5406. Carrier concentration disturbances in semiconductors. G. G. E. LOW. *Proc. Phys. Soc. [London] B*, **68**, *Pt* 5, 310–14 (*May*, 1955).

Carrier concentration disturbances in semiconducting filaments are discussed by reference to the composition of the current at the end contacts. Four types of disturbance must be envisaged, of which carrier injection is the best known. Carrier exclusion and extraction have also been experimentally observed, but carrier accumulation has not yet been reported. These phenomena are discussed in terms of a unified set of equations on the assumption that the disturbances are much smaller than the equilibrium concentration of majority carriers. A.

537.311.33 : 548.7 : 538.56

Propagation and plasma oscillation in semiconductors with magnetic fields. *See Abstr.* 5524

537.311.33 : 538.22

Magnetic susceptibility measurements on germanium. *See Abstr.* 5510

537.311.33 : 548.7

5407. Fast particle irradiation of germanium semiconductors. H. Y. Fan and K. Lark-Horovitz. *Defects in crystalline solids* [*Bristol*] 232–45. *See Abstr.* 5707 (1955).

Irradiation of germanium semiconductors of various initial concentrations of electrons and holes, with 9·5 MeV deuterons, 4·5 MeV electrons and about 5 MeV α-particles, is discussed. The results are analysed in terms of the efficiency of carrier removal or carrier addition as a function of the Fermi-level of the starting material and the shift of the Fermi-level during irradiation. In this way the type of levels and the energy distribution of localized states introduced in the forbidden gap can be obtained. This in turn can be correlated with the number of displacements as calculated from theory. The defects produced by irradiation depend on the type of particle used and the duration of irradiation. Equilibrium and non-equilibrium conditions during irradiation and after irradiation at various temperatures are discussed, and it is concluded that the process of healing cannot be described by a simple annealing of defects introduced, but depends on the temperatures at which the healing is observed. It follows that the imperfections cannot all be isolated vacancies and interstitials. Deuteron irradiation seems to introduce a more complicated spectrum of energy levels than electron bombardment, indicating that various types of imperfections are produced. A.

537.311.33

5408. Measurement of the lifetime of minority carriers in germanium. W. G. Spitzer, T. E. Firle, M. Cutler, R. G. Shulman and M. Becker. *J. appl. Phys.*, **26**, *No.* 4, 414–17 (*April*, 1955).

Two methods are described. One depends on pulse injection of carriers in a filament and detection, after a known time, at a collector. The second makes use of the decay of the conductivity modulation caused by minority carriers after injection at a single contact. Both measure the lifetime in a small region rather than the average value over a large part of the sample. A.

537.311.33

5409. Cyclotron resonance of electrons and holes in silicon and germanium crystals. G. Dresselhaus, A. F. Kip and C. Kittel. *Phys. Rev.*, **98**, *No.* 2, 368–84 (*April* 15, 1955).

An experimental and theoretical discussion is given of the results of cyclotron resonance experiments on charge carriers in silicon and germanium single crystals near 4°K. A description is given of the light-modulation technique which gives good signal-to-noise ratios. Experiments with circularly polarized microwave radiation are described. A complete study of anisotropy effects is reported. The electron energy surfaces in germanium near the band edge are prolate spheroids oriented along ⟨111⟩ axes with longitudinal mass parameter $m_l = (1{\cdot}58 \pm 0{\cdot}04)m$ and transverse mass parameter $m_t = (0{\cdot}082 \pm 0{\cdot}001)m$. The electron energy surfaces in silicon are prolate spheroids oriented along ⟨100⟩ axes with $m_l = (0{\cdot}97 \pm 0{\cdot}02)m$; $m_t = (0{\cdot}19 \pm 0{\cdot}01)m$. The energy surfaces for holes in both germanium and silicon have the form

$$E(k) = Ak^2 \pm [B^2k^4 + C^2(k_x^2k_y^2 + k_y^2k_z^2 + k_z^2k_x^2)]^{\frac{1}{2}}.$$

For germanium, $A = -(13{\cdot}0 \pm 0{\cdot}2)(\hbar^2/2m)$, $|B| = (8{\cdot}9 \pm 0{\cdot}1)(\hbar^2/2m)$, $|C| = (10{\cdot}3 \pm 0{\cdot}2)(\hbar^2/2m)$; and for silicon, $A = -(4{\cdot}1 \pm 0{\cdot}2)(\hbar^2/2m)$, $|B| = (1{\cdot}6 \pm 0{\cdot}2)(\hbar^2/2m)$, $|C| = (3{\cdot}3 \pm 0{\cdot}5)(\hbar^2/2m)$. A discussion of possible systematic errors in these constants is given. A.

537.311.33

5410. Properties of germanium doped with nickel. W. W. Tyler, R. Newman and H. H. Woodbury. *Phys. Rev.*, **98**, *No.* 2, 461–5 (*April* 15, 1955).

The temperature dependence of electrical resistivity in p- and n-type nickel-doped germanium crystals indicates that nickel introduces two acceptor levels in germanium at $0{\cdot}22 \pm 0{\cdot}01$ eV from the valence band and $0{\cdot}30 \pm 0{\cdot}02$ eV from the conduction band. Ionization energies deduced from infrared photoconductivity studies at 77°K are in agreement with the values obtained from resistivity measurements. N-type samples show higher photosensitivity than p-type samples and demonstrate quenching effects. The distribution coefficient for nickel in germanium is about $2{\cdot}3 \times 10^{-6}$. A.

537.311.33

5411. Measurement and interpretation of conductance of p-type inversion layers on germanium. G. A. deMars, H. Statz and L. Davis, Jr. Letter in *Phys. Rev.*, **98**, *No.* 2, 539–40 (*April* 15, 1955).

Stable inversion layers on n-type germanium can be produced by treatment with $O_2 + O_3$. The conductance values of the inversion layers on the 0·4 cm n-regions of grown junction p–n–p transistors were measured for various bias voltages. For each change of voltage, times of up to a few minutes for an equilibrium conductance to be reached were needed. The model for the surface assumes an oxide layer with outer surface states arising from absorbed gas atoms and inner surface states at the oxide–Ge interface. C. A. Hogarth

537.311.33

5412. Structure of surface states at the germanium-germanium oxide interface. H. Statz, L. Davis, Jr and G. A. deMars. Letter in *Phys. Rev.*, **98**, *No.* 2, 540–2 (*April* 15, 1955).

See preceding abstract. The surface states model is expanded and the changes of inversion-layer conductance with time are explained by the time taken for change transfer across the oxide layer. For a range of bias voltages the total charge in the surface states is of order $2{\cdot}5 \times 10^{11}$ cm^{-2}. C. A. Hogarth

537.311.33

5413. Drift mobility of conduction electron[s] in KCl. H. Kawamura and M. Onuki. Note in *J. Phys. Soc. Japan*, **10**, *No.* 2, 162–3 (*Feb.*, 1955).

Electron-hole pairs are produced in a KCl crystal by bombardment with a pulsed electron beam, and the drift velocity of the secondary electrons is

measured as a function of applied voltage. The mobility at room temperature is about 3 cm^2/volt.sec, in fair agreement with theoretical estimates.

E. H. SONDHEIMER

537.311.33

5414. The physical chemistry of lead sulphide in relation to its semiconducting properties. J. BLOEM, F. A. KRÖGER AND H. J. VINK. *Defects in crystalline solids* [*Bristol*] 273–82. *See Abstr.* 5707 (1955).

The semiconducting properties of lead sulphide single crystals have been measured after heating at various temperatures in controlled atmospheres. Thermoelectric power measurements indicate an energy gap of 0·3 eV at room temperature, and an effective electron and hole mass of about 0·25 of the electron mass in free space. With the use of the theory of Kröger, Vink and van den Boomgaard [Abstr. 2738 (1955)] it was possible to deduce the width of the energy gap and the position of the various vacancy levels as a function of temperature, from 800 to 1 200°K. A.

537.311.33

5415. Adsorption and surface potential of semiconductors. I. Photo-enhanced adsorption of oxygen and change of contact potential of ZnS phosphors with illumination. A. KOBAYASHI AND S. KAWAJI. *J. Phys. Soc. Japan*, **10**, *No.* 4, 270–3 (*April*, 1955).

When ZnS phosphor containing 10^{-2} mol% of Cu was irradiated in oxygen gas by light with wavelengths lying within the characteristic absorption band of the host crystal, photo-enhanced adsorption and increase of the surface potential (decrease of the work function) of the crystal were observed. If it is assumed that the lowering of the potential energy of adsorption of oxygen is equal to the increased amount of surface potential, the photo-enhanced adsorption can be explained semi-quantitatively. The change of the surface potential of ZnS with illumination increased with pressures of oxygen and decreased with temperature. A.

537.311.33 : 537.312.5

5416. Properties of zinc phosphide Zn_3P_2 in crystalline form. J. LAGRENAUDIE. Letter in *J. Phys. Radium*, **16**, *No.* 3, 234–5 (*March*, 1955) In French.

Crystals of about 1 mm in size obtained by vacuum distillation of Zn_3P_2 show semiconduction with impurity-activation energies of 0·3 and 0·6 eV and intrinsic activation energy of 1·15 eV. Distillation produces *p*-type crystals from *n*-type material hole mobility having an upper limit of 10 $cm^2/V.sec^{-1}$. The photoconduction threshold is at 1·1 μ. Photoconductive, photovoltaic and photomagnetic effects are investigated. G. F. J. GARLICK

537.311.62

5417. Skin effect in a ferromagnetic conductor with simultaneous premagnetization by constant perpendicular fields. I. TJUTINS AND L. ULMANIS. *Latv. PRS Zinat. Akad. Vēstis*, **1954**, *No.* 2, 125–8. In Latvian with summary in Russian (½ p.).

In previous articles [L. R. Neiman: *Skin effect in ferromagnetic bodies.* Moscow, Leningrad (1949); S. D. Margolin: *Zh. tekh. Fiz.*, **18**, *No.* 10 (1948); Abstr. 2096B (1949)] experimental results were quoted and proposals were made about the calculation of the skin effect in ferromagnetic bodies under simultaneously applied mutually perpendicular alternating and steady magnetic fields. It was concluded that mutual orientation of the fields was of no significance. It is here shown experimentally that Neiman's formulae for determining the effective resistance of a ferromagnetic cylinder in the presence of skin effect is valid for such cases. S. C. DUNN

537.312.5

5418. On the photoconductivity of BaO. M. SAKAMATO. *Vide*, **9**, 109–12 (*July–Sept.*, 1954) In French and English.

Experimental investigation of the variation of photoconductivity and photoemission of polycrystalline BaO with the wavelength of the incident light. An energy-level diagram is suggested to explain the results. J. DUTTON

537.312.5

5419. Photomagnetoelectric effect in selenium barrier-layer photopiles. G. BLET. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 743 (*Feb.* 14, 1955) In French.

Summarizes the effects on the current in a selenium photopile caused by the application of a magnetic field parallel to the plane of the photopile. J. DUTTON

537.312.5

5420. Measurement of shot noise in CdS crystals. C. I. SHULMAN. *Phys. Rev.*, **98**, *No.* 2, 384–6 (*April* 15, 1955).

The noise power spectrum associated with photoconduction current in CdS crystals with indium electrodes is found to flatten off at low frequencies at a value that corresponds closely to the noise inherent in the photon absorption process itself plus that associated with the random nature of the carrier recombination process. It is found that the noise power is not a unique function of the photoconduction current, but varies as the square of the applied voltage and linearly with light intensity, as suggested by a simple model not unlike that of the photomultiplier. A.

537.312.5

5421. Temperature dependence of the width of the band gap in several photoconductors. R. H. BUBE. *Phys. Rev.*, **98**, *No.* 2, 431–3 (*April* 15, 1955).

The temperature dependence of the width of the forbidden band gap has been determined, between 90 and 400°K, for cadmium sulphide, cadmium selenide, cadmium telluride and zinc selenide, by measurement of photosensitivity as a function of wavelength. The location of the maximum photosensitivity, often very sharp, at the wavelength corresponding approximately to the width of the band gap, makes this method very convenient for the determination. Structure exists in the photosensitivity maxima of cadmium sulphide and cadmium selenide, suggesting the existence of double conduction or valence bands. A.

537.312.5

5422. Localized photoeffect in PbS photocells. E. S. RITTNER AND S. FINE. Letter in *Phys. Rev.*, **98**, *No.* 2, 545–6 (*April* 15, 1955).

537.312.5

5423. Effect of oxygen gas on the photoconductivity of BaO. M. SAKAMOTO, S. KOBAYASHI AND S. ISHII. Letter in *Phys. Rev.*, **98**, *No.* 2, 552–3 (*April* 15, 1955).

The peak photoconductivity response of a BaO cathode coating for $h\nu = 3{\cdot}7$ eV decreases rapidly with introduction of oxygen into the vacuum system and suggests this response is due to surface states.

G. F. J. GARLICK

537.312.5 : 621.383.27

5424. Fatigue of photomultipliers under pulsed operation. R. WILSON. Letter in *J. sci. Instrum.*, **32**, *No.* 4, 152–3 (*April*, 1955).

It is suggested that the assumption that fatigue depends only on average current is not valid and that pulsed operation can cause greater fatigue than that given by average current. G. F. J. GARLICK

537.312.8 : 536.48

5425. Oscillatory thermomagnetic properties of a bismuth single crystal at liquid helium temperatures. M. C. STEELE AND J. BABISKIN. *Phys. Rev.* **98**, *No.* 2, 359–67 (*April* 15, 1955).

Measurements of the thermoelectric power, thermal conductivity, and electrical resistance have been made on a bismuth crystal in magnetic fields up to 13 kilogauss at liquid helium temperatures. The results for two newly discovered effects, namely the oscillatory magnetic field dependence of both the thermoelectric power and the thermal conductivity are presented in detail. The crystal was mounted transverse to the field with the trigonal axis parallel to the crystal length. The heat current was also parallel to the crystal length. Most of the data were taken with the magnetic field parallel to one of the crystalline binary axes where only one oscillating component was found. For this orientation the oscillations in the two thermomagnetic properties were periodic in H^{-1} with a period of $7{\cdot}1\times10^{-5}$ gauss^{-1}. This result is compared to the calculated period obtained from susceptibility oscillations (de Haas–van Alphen effect) of bismuth and found to agree very well. Temperature and field dependence of the amplitude of the oscillatory effects are discussed. A.

537.323

5426. On the thermoelectric power of cesium antimonide. T. SAKATA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 6, 1031–2 (*Nov.–Dec.*, 1954).

By means of classical theory the results together with the conductivity activation energy are used to calculate a value of Hall effect R and the calculated values are compared with the experimental results. The general form of curves of $\log R$ *v.* $1/T$ is as expected but numerical agreement is not good.

C. A. HOGARTH

537.323 : 537.311.31

5427. Thermoelectric power and electrical resistivity of dilute alloys of silicon in copper, nickel, and iron. C. A. DOMENICALI AND F. A. OTTER. *J. appl. Phys.*, **26**, *No.* 4, 377–80 (*April*, 1955).

Data are given on the dilute alloys, Cu–Si, Ni–Si and Fe–Si, from −195° to +500°c (and higher for some of the alloys). The Cu–Si thermopower at first decreases with increasing Si content and then again increases, the minimum being at about 2 or 3 atomic % Si, depending on the temperature. The Cu–Si resistivity is typical of Cu-base alloys, the resistivity increases per atomic % Si changing from $7{\cdot}2\mu\Omega$ cm at −190°c to $8{\cdot}7\mu\Omega$ cm at 840°c. The thermopower and resistivity curves for Ni–Si show a characteristic kink at the Curie temperature of each alloy. The Fe–Si thermopowers are positive at lower temperatures and become negative at a temperature T_0 which decreases with increasing Si content. Furthermore, T_0 changes from about 300°c for pure iron to about +70°c for 2 atomic % Si. The resistivity of Fe–Si alloys increases faster than linearly with temperature, and this is also the case for the Ni–Si alloys below the Curie temperature. Above the Curie temperature, the Ni–Si resistivities vary linearly with temperature. The increase in resistivity per atomic % Si in Fe is $10{\cdot}5\mu\Omega$ cm at all temperatures within the measured range. A.

ELECTRIC DISCHARGES 537.52

537.525

5428. High-frequency gas discharge plasma in hydrogen. D. J. ROSE AND S. C. BROWN. *Phys. Rev.*, **98**, *No.* 2, 310–16 (*April* 15, 1955).

The high-frequency electric field required to maintain a hydrogen plasma has been measured as a function of pressure and plasma electron density. A theory of the plasma based on a solution of the Boltzmann transport equation has been developed to predict this field; it agrees satisfactorily with experiment. The theory has no adjustable parameters, and uses only the probabilities of collision, excitation, and ionization of the gas by electrons, and the ionic mobility. A.

537.525

5429. Noise from hot-cathode discharges. THONG SAW PAK. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 5, 292–6 (*May*, 1955).

A study has been made of the low-frequency noise which occurs in hot cathode discharges through mercury vapour at low pressure. Under non-saturated conditions the whole plasma fluctuates in potential coherently, probably on account of fluctuations of the cathode sheath. The effects of these fluctuations on probes, used under different conditions, are discussed. There is evidence for the existence of a second type of noise, associated more directly with fluctuations of ion sheaths on the wall or probes. A.

537.525.3 : 537.525.72 : 537.525.8

5430. Dependence on the nature of the electrode surface of the Joshi effect in oxygen at different gas pressures. S. R. MOHANTY, T. S. NAGARJUNAN, R. SRINIVASAN AND G. SRINIVASAN. Note in *J. Phys. Soc. Japan*, **10**, *No.* 2, 163–4 (*Feb.*, 1955).

Describes expts. on the effect of illumination on ozonizer-tube corona discharges in oxygen. The change in discharge current due to the illumination was studied with tube walls of soda glass and the effect of contamination with KCl was also investigated.

J. D. CRAGGS

537.525.5

5431. Ambipolar diffusion in a magnetic field. A. SIMON. *Phys. Rev.*, **98**, *No.* 2, 317–18 (*April* 15, 1955).

Diffusion of ions in a plasma across a magnetic field is shown to be not ambipolar in character in most arc experiments. Owing to the highly anisotropic conductivity of the medium, the ions diffuse across the field at their own intrinsic rate. Space-charge neutralization is maintained by slight adjustments of the currents in the direction of the magnetic field lines. The discrepancy between theory and experiment noted by Bohm is thus resolved and no additional mechanisms, such as plasma oscillations, need be postulated. A.

537.525.8

5432. Note on an experiment by Rayleigh on active nitrogen. D. T. STEWART AND K. G. EMELEUS. *Trans Faraday Soc.*, **51**, *Pt* 4, 491–2 (*April*, 1955).

Some difficulties arising in interpretation of Rayleigh's experiment on production of active nitrogen in low-pressure d.c. glow discharges have been partly removed by examination of the near infrared spectrum of the discharges. In particular, the negative glow, which is believed to give a high yield of active nitrogen, has been shown to contain neutral atoms. A.

X-RAYS 537.531

537.531 : 535.33/.34

5433. X-ray emission and absorption spectra of carbon. J. BAČKOVSKÝ. *Czech. J. Phys.*, **4**, *No.* 3, 300–10 (*Sept.*, 1954) In German.

X-ray emission and absorption wavelengths for various modifications of carbon have been collected and compared, and are interpreted in terms of transitions between optical and X-ray energy levels in the carbon atom. See Abstr. 4710 (1955). A. R. STOKES

537.531 : 535.33

5434. X-ray critical-absorption and emission energies in keV. S. FINE AND C. F. HENDEE. *Nucleonics*, **13**, *No.* 3, 36–7 (*March*, 1955).

A table of values (to 1 eV) for the K and L series of all elements, derived from previously published results; a few values are interpolated, using Moseley's law.

537.531 : 535.33

5435. On the L-absorption spectra of gold in the pure metal and in gold–palladium alloys. C. MANDE. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 11, 1205–7 (*March* 14, 1955) In French.

For the alloys studied (88% Au and 55% Au) the three L discontinuities are displaced towards longer wavelengths from their position for the pure metal. The form of the L_{111} discontinuity is also modified.

A. E. DE BARR

537.531 : 539.165

5436. Beta-ray-excited low-energy X-ray sources. L. REIFFEL. *Nucleonics*, **13**, *No.* 3, 22–4 (*March*, 1955).

The use of β-rays to excite bremsstrahlung and fluorescent radiation in suitable heavy targets, is described. Spectra excited in Pb and Ba targets by Sr^{90}–Y^{90} sources under various conditions are shown. Methods of enhancing the fluorescent monokinetic radiation with respect to the continuous bremsstrahlung are discussed and source designs utilizing these principles are given. Up to 0·1 mc of X-rays per mc of β-particles may be obtained. L. R. SHEPHERD

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

5437. The influence of the space charge in an electron beam accelerated in a constant electrostatic field up to energies of several MeV. M. SANGSTER. *Appl. sci. Res. B*, **4**, *No.* 4, 261–70 (1955).

To realize a pulsed electron beam of high energy (2·5 MeV) and great intensity (~1 A) the influence of space charge has to be taken into account. A calculation in this article shows that at an average field strength in the acceleration tube of 10^6 V/m the influence of the space charge begins to play a dominating part at a current density of 2 A/cm^2. A.

537.533.3

5438. On the focusing of electrified particles. A. YU. ISHLINSKIĬ. *Dokl. Akad. Nauk SSSR*, **96**, *No.* 4, 721–4 (1954) In Russian.

Given a magnetic field which is everywhere normal to the plane xy and which in that plane is a function of x only, the problem is to determine $H(x)$ such that all particles leaving $x = 0$, $y = 0$ and travelling in the plane with "specific momentum" ($H\rho$) shall arrive at $x = 0$, $y = l$, the y axis itself being included as a ray. It is shown that the required form is $H(x)/(H\rho) = (\pi^2/l^2)(x - \pi^2x^3/2l^2 + 9\pi^4x^5/40l^4 \ldots)$.

J. C. E. JENNINGS

537.533.3

5439. Relativistic aberration functions and the normal coefficients of electron-optical aberrations. O. I. SEMAN. *Dokl. Akad. Nauk SSSR*, **96**, *No.* 6, 1151–4 (1954) In Russian.

"Normal" here has the same meaning as "reduced" in Abstr. 8242 (1952). Relativistically correct expressions are given for the fourth-order point eiconal and for the eight third-order coefficients of transverse aberration, for an axially symmetric electric + magnetic lens field. The e.s. field appears to be restricted to that of the unipotential type of lens.

J. C. E. JENNINGS

537.533.3 : 621.385.833

5440. Use of space charge in electron optics. E. A. ASH. *J. appl. Phys.*, **26**, *No.* 3, 327–30 (*March*, 1955).

The electron optical properties of a cylindrical space charge cloud are derived. The possibility of achieving a system free from either spherical or chromatic aberration by combining a space charge lens with a space-charge-free converging lens is examined. It is concluded that the achromatization of a thin electric or magnetic lens is possible only if the resultant action of the combination is divergent. The correction of the spherical aberration of a high-quality lens, such as an electron microscope objective, is shown to be impossible on account of electron interaction effects. A.

537.533.331

5441. Theoretical resolving power of an electrostatic immersion lens. A. SEPTIER. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 11, 1200–2 (*March* 14, 1955) In French.

The resolving power of an electrostatic immersion objective lens considered as the diameter of the disk of least confusion is five times that of the resolving power considered as the diffraction limit. Calculations of the angular distribution of electrons leaving an object, however, show that the most favourable plane for viewing an image is not where the overall diameter of the beam is smallest but where an intense central spot is surrounded by a large but weakly illuminated halo. This gives a resolving power of the order of the diffraction limit.

A.E.I. RESEARCH LABORATORY

537.533.35

5442. Investigation of the mechanism of image formation in the electron microscope. I. G. STOYANOVA AND A. I. FRIMER. *Dokl. Akad. Nauk SSSR,* **94,** *No.* 3, 459–62 (1954) In Russian.

Measurements were made of the ratio of electrons focused on to a photographic plate to the number incident on the specimen—amorphous quartz evaporated on to collodion—as a function of specimen thickness, electron voltage and lens aperture; results are given graphically for bright field and dark field illumination. Measurements were also made by the method of Abstr. 371 (1951). Contrast curves are given, calculated from the experimental results; these show, *inter alia,* that for very thin specimens dark field illumination is preferable. J. C. E. JENNINGS

537.533.35

5443. A theory on image formation of electron microscope. R. UYEDA. *J. Phys. Soc. Japan,* **10,** *No.* 4, 256–64 (*April,* 1955).

Aims at providing a consistent basis to all theories of electron-microscope image formation, on the principle of building up an image of a specimen from images of atoms which make up the specimen. The result obtained by developing this idea indicates that an actual image is composed of two ideal images, one of which shows phase contrast and the other contrast due to scattering absorption. By applying this result, bright and dark field images are explained. Not only images of amorphous specimens but those of crystalline specimens are treated. A.

537.533.35 : 621.385.833

5444. A simplified magnetic transmission microscope for electrons from 40 kV to 60 kV. K. MÜLLER AND E. RUSKA. *Z. wiss. Mikr.,* **62,** *No.* 3, 205–19 (*Jan.,* 1955) In German.

A detailed description of an electron microscope produced by Siemens and Halske A.G. for routine use at moderately high performance. A condenser lens is dispensed with, so that only two magnetic electron lenses are employed (objective and projector). The projector contains a set of polepieces, which can be interchanged under vacuum, allowing a magnification range of 300–30 000×. The beam voltage can be set at three values, 40, 50 and 60 kV. A resolving power of 30 Å is claimed with favourable specimens. Electron diffraction can also be obtained without moving the specimen. Photographs are taken either on 35 mm film or on 6·5×9 cm plates in a 12-plate cassette. V. E. COSSLETT

537.533.35

5445. A six gap β-ray spectrometer. O. B. NIELSEN AND O. KOFOED-HANSEN. *K. Danske Vidensk. Selsk., mat.-fys. Medd.,* **29,** *Paper* **6,** 19 *pp.* (1955).

A β-ray spectrometer is described which effectively consists of six double-focusing spectrometers in parallel, utilizing the same source and detector in order to obtain a large solid angle of collection. This is accomplished by having six gaps symmetrically disposed in an annular cylindrical magnet. The geometry of the instrument is discussed in detail and the profile of the pole faces is machined to give focusing over a large aperture and to minimize the defocusing effects over the fringing fields. The source and detector are on the axis of the cylinder outside the field. Detection is by means of a sodium iodide crystal and photomultiplier, a second photomultiplier behind the source allows a large solid angle for use in coincidence experiments. The setting up of the instrument for best results is described and possibilities of further instruments using the same principles in pair spectrometry, etc., are discussed. The performance of the instrument is compared with the theoretical predictions and results are given. A transmission of 9% is obtained at a resolution of 1·6%. In coincidence work a transmission of as high as 3% in the coincident spectrum is obtainable.

D. R. CHICK

537.533.74

5446. The nuclear scattering of electrons by uranium. H. N. YADAV. Letter in *Proc. Phys. Soc.* [*London*] *A,* **68,** *Pt* 4, 348 (*April,* 1955).

Differential cross-sections have been computed for the Mott scattering (relativistic scattering by a point charge) in the region 0·145 mc^2–20 mc^2. G. E. BROWN

537.533.74

5447. Electron scattering from the proton. R. HOFSTADTER AND R. W. MCALLISTER. Letter in *Phys. Rev.,* **98,** *No.* 1, 217–18 (*April* 1, 1955).

Elastic scattering at 100, 188 and 236 MeV gives results lying in between the Mott curve for relativistic scattering by a point charge and the curve for relativistic scattering by a point particle with a point anomalous moment. The results can be obtained by assuming the proton to have a structure.

G. E. BROWN

537.533.75

5448. Relation to diffusion measurements of some beta-ray absorption phenomena. A. E. BERKOWITZ. *J. appl. Phys.,* **26,** *No.* 4, 403–5 (*April,* 1955).

The absorption in thin layers of nickel, aluminium, and cobalt of β-rays from Co^{60} was measured in connection with the use of the surface counting method of determining diffusion coefficients. Data was obtained for foils and for evaporated and electroplated layers. In all cases the activity increased between 0 and 4 mg/cm². A discrepancy was noted between the data for foils and those for evaporated and electroplated layers. It is shown that this general behaviour is predicted by simple scattering and absorption expressions. The implications of these data for the use of the surface counting method are discussed.

A.

537.533.8 : 539.16.08 : 621.385.032.216

5449. The use of radioactive isotopes in a study of evolution of strontium from strontium oxide under electron bombardment. S. Yoshida, N. Shibata, Y. Igarashi and H. Arata. *Vide*, **9**, 106–8 (*July–Sept.*, 1954) In French and English.

(1) For constant voltage and temperature, the rate of evolution is $\propto$ bombarding current. (2) Rate of evolution increases exponentially with T between 250 and 450°C, with an activation energy of 0·8 eV. (3) 150 eV electrons are much more effective than 500 eV electrons. (4) The number of Sr atoms per electron is about $1{\cdot}5\times10^{-5}$ at 150 eV and 3·5 mA current. A. H. W. BECK (R)

537.534

5450. Linear accelerator phase oscillations. J. S. Bell. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M*114, 10 *pp.* (1954).

The axial motion of a particle in a linear accelerator is analysed taking account of the detailed distribution of accelerating field. It is shown that the frequency and rate of damping of small phase oscillations do not depend on the details of the distribution. A.

537.534

5451. Statistical analysis of optical alignment in a linear accelerator. L. B. Mullett. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. GP/M* 170, 5 *pp.* (1954).

In satisfying the stringent conditions of alignment to an axis in a linear accelerator employing alternating gradient focusing, optical methods are an obvious solution. The probability relationships are developed for the optical method which is being evolved for the 600 MeV proton linear accelerator. A.

537.534

5452. External proton beam of the cosmotron. O. Piccioni, D. Clark, R. Cool, G. Friedlander and D. Kassner. Letter in *Rev. sci. Instrum.*, **26**, *No.* 2, 232–3 (*Feb.*, 1955).

A method for extracting the 2·5 k MeV proton beam of the Brookhaven cosmotron is described. The beam traverses a 1 in. Lucite target which displaces the beam inward after 1 revolution by 4 in. to enter the gap of a 6000 gauss electromagnet. This causes a deflection of 3° outwards to reach the outside of the chamber after a further 90° of path. A second magnet is to be placed here to cause a further deflection of 8° outwards for final extraction. 45% of the internal beam has been successfully deflected into an area 2 in. × 5 in., the proposed gap of the second magnet. J. H. FREMLIN

537.534 : 621.317.31.083.7 : 621.319.33

5453. A versatile top terminal equipment for an electrostatic accelerator. B. Millar, K. Firth and D. R. Chick. Note in *J. sci. Instrum.*, **32**, *No.* 3, 120–1 (*March*, 1955).

Extensions to a telemetering system for an electrostatic generator are described. The equipment has been used to measure the currents flowing to and from the h.v. electrode of the generator, with an accuracy of 5%. D. R. CHICK

537.534.3 : 621.385.833

5454. Electrostatic strong-focusing lens. M. L. Bullock. *Amer. J. Phys.*, **23**, *No.* 5, 264–8 (*May*, 1955).

The basic principles are described to illustrate a modern application of several classical concepts. The motion of an ion in the electrostatic field is described in terms of optical analogies to thick lenses. The astigmatism of such lenses is discussed, and the two-section lens designed for use with the Naval Research Laboratory 5 MeV Van de Graaff proton beam is described. A.

537.534.3

5455. A mass spectrometer for the isotopic analysis of hydrogen containing a low concentration of deuterium. P. Reynolds. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. GP/R*1449, 10 *pp.* (1954).

A mass spectrometer suitable for the comparison of isotope ratios in samples of hydrogen gas containing only a low concentration of deuterium is fully described. High stability of the measured isotope ratio for a sample is achieved, so that in the region of concentration of 0·015 mol % D samples can be compared for their deuterium content to a precision of $\pm0{\cdot}000\,07$ mol % D. A.

537.534.3

5456. A two-stage magnetic analyzer for isotopic ratio determinations of 10^4 to 1 or greater. F. A. White and T. L. Collins. *Appl. Spectrosc.*, **8**, *No.* 4, 169–73 (*Nov.*, 1954).

Effects of small-angle elastic scattering are minimized by using two-stage, 180°, deflection; fields are stabilized by nuclear-resonance probes. Velocity selection is not employed. Probability that an ion is elastically scattered "through one mass unit" in one stage was found to be $\simeq10^{-4}$, in good agreement with theory. Results indicate good abundance sensitivity for adjacent isotopes, superior to that obtained in comparable single-stage analysers. N. M. KING

537.534.3

5457. New time-of-flight mass spectrometer. H. S. Katzenstein and S. S. Friedland. *Rev. sci. Instrum.*, **26**, *No.* 4, 324–7 (*April*, 1955).

A spectrometer based on principles previously described has been constructed with two major modifications to facilitate appearance potential measurements. These modifications are (1) an axial electron beam is pulsed through an ionization chamber utilizing techniques of Fox, *et al.*, and (2) a gated ion detector is employed to allow for integration of the resolved ion current from successive cycles. The instrument has been constructed of stainless steel to allow for measurements on chemically active gases. Theoretical resolution, limited by thermal energies of the ions, appears to be well over mass 200. Preliminary experimental work has verified this up to the region of mass 100. Ionization potentials, using the difference method, have been obtained from various gases that are in agreement with the spectroscopic data to within 0·05 V. A.

537.534.3 : 621.384.62

5458. Investigation of the collector characteristics of the palletron. V. K. Shtein. *Zh. tekh. Fiz.*, **24**, *No.* 6, 1062–8 (1954) In Russian.

After a brief description of the palletron [see Abstr. 1547B (1948); *J. appl. Phys.*, **19**, 187–90 (*Feb.*, 1948)] and reference to previous publications, the transient régime for a change in loading is displayed graphically. In the case when the tube is used as a mass

spectrometer with a pulsed accelerating force the possible resolution in mass is calculated. This resolution depends in the limit on the time duration of the pulse. S. C. DUNN

537.534.75

5459. The range-energy relation in nuclear emulsions. R. R. DANIEL, E. C. GEORGE AND B. PETERS. *Proc. Indian Acad. Sci. A*, **41**, *No.* 2, 45–8 (*Feb.*, 1955).

The use of large stacks of stripped emulsions enables the range of energetic particles to be measured. An accurate range-energy relation is therefore required. The known relation up to 21 MeV is extrapolated past the isolated point for 342·5 MeV protons by comparing the theoretical calculations for aluminium and lead with the known relation below 21 MeV. It is found that the square of the range in emulsion (in mm) divided by the product of the theoretical stopping powers of aluminium and lead (in g/cm^2) is a constant independent of energy. This constant enables the relation to be constructed from the calculations up to a proton energy of 2 BeV. D. J. PROWSE

537.534.75

5460. Range straggling in nuclear track emulsion. W. H. BARKAS, F. M. SMITH AND W. BIRNBAUM. *Phys. Rev.*, **98**, *No.* 3, 605–10 (*May* 1, 1955).

The contributions to the range variance in nuclear track emulsion have been studied and the magnitude of the various effects calculated. Bohr straggling is found to be the most important effect when the energy is high, but for slow particles, a number of others combine to dominate the straggling. Range errors caused by distortion are also studied. Measurements are reported on the straggling of eighteen particle groups consisting of protons, pions and muons. With the particle mass and velocity as variable parameters, the theoretical estimates are tested and a detailed accounting of the contributions to the straggling is made. A.

537.534.75

5461. Energy distribution of protons due to collision energy loss. K. C. HINES. Letter in *Phys. Rev.*, **97**, *No.* 6, 1725–7 (*March* 15, 1955).

A theoretical calculation of the probability distribution of the energy loss of protons passing through layers of material. An integral curve deduced for the energy distribution of 0·426 3 MeV protons passed through $3{\cdot}795\times10^{-5}$ g/cm^2 of Al is compared with experimental results, and shows good agreement, whereas the curve deduced from the Landau theory shows some discrepancy. P. ROTHWELL

537.534.75

5462. Stopping cross sections of metals for protons of energies from 400 to 1000 keV. D. W. GREEN, J. N. COOPER AND J. C. HARRIS. *Phys. Rev.*, **98**, *No.* 2, 466–70 (*April* 15, 1955).

The stopping cross-sections of manganese, copper, germanium, selenium, silver, tin, antimony, gold, lead and bismuth are reported. The cross-sections are roughly proportional to the square root of the atomic number of the stopping element and inversely proportional to the velocity of the incident protons. There is some evidence that the stopping cross-section increases more rapidly than $Z^{\frac{1}{2}}$ as the various p shells are filled. A.

537.534.75

5463. On the range-energy relation for slow α-particles in argon. G. BERTOLINI AND M. BETTONI. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 644–50 (*April*, 1955).

The range-ionization curve for α-particles in argon has been obtained in the region of 0·25–3·5 MeV. A grid ionization chamber containing two sources of α-particles was used for measurements. The sources were placed in such a way as to emit particles in the direction of and perpendicularly to the field. The different rise time of the tracks running parallel and perpendicular to the electric field gives the range of the α-particles, while the amplitude gives the energy. The range-energy curve is obtained by assuming a strict proportionality between the total ionization produced and the energy of the α-particle. By comparison with the Bethe range-energy curve in air, the stopping power in argon is obtained. A.

537.534.75

5464. New method for measuring the α-particle range and straggling in liquids. G. ANIANSSON. *Phys. Rev.*, **98**, *No.* 2, 300–2 (*April* 15, 1955).

The ranges of Po α-particles in water and five other liquids have been measured with a new method involving a steel surface as support for the α-source and a $CaWO_4$ crystal surface as detector for the α-particles. The surfaces are optically plane and parallel and constitute the walls of a microcell for the liquid. The range obtained at 25°C in water was 39·9 μ, 2·7% longer than the value 38·8 μ, computed with the Bragg law from range measurements in gaseous hydrogen and oxygen. In the other five liquids the ranges obtained also were longer (2·3–4·6%) than the correspondingly computed Bragg law values. A.

537.534.79

5465. The charges carried by fast nitrogen, oxygen and fluorine ions passing through matter. K. G. STEPHENS AND D. WALKER. *Proc. Roy. Soc. A*, **229**, 376–86 (*May* 10, 1955).

The distributions of charges carried by fast nitrogen, oxygen and fluorine ions after passing through a thin organic film have been investigated by magnetic analysis. The ions, which were accelerated in the Birmingham cyclotron, had velocities between 0·86 and $1{\cdot}43\times10^9$ cm/sec, corresponding to kinetic energies in the range 6·2 to 20·4 MeV, and carried average charges between 4·86 and 6·63 positive electron units after emerging from the film. The dependence of the ionic charge on the velocity and on the atomic number of an ion passing through matter is found to be in good qualitative agreement with the criterion of Lamb. This states that the velocity of the ion must be such that $\frac{1}{2}mv^2 \gtrsim I$, where m is the electron mass and v the velocity of the ion, if an electron of binding energy I is to be removed from the ion. For any of the ions used, not more than two or three charge states were found to occur with large probability at a given velocity, indicating a strong variation with ionic charge of the cross-sections for electron capture and for electron loss by the ion. The average charges carried by the ions are compared with the statistical theory of Brunings, Knipp and Teller (1941). A.

DISCHARGE TUBES . COUNTERS 537.54

537.542 : 539.185.08

5466. Proportional neutron counters. B. H. FLOWERS. *Atomic Energy Canada Rep., No.* 62, 17 *pp.* (*Sept.* 12, 1946).

The counters designed for use in the pile in the starting-up period, and the auxiliary apparatus to be used with them, are described. An account of their behaviour in a standard arrangement is given and some typical characteristics are presented. The counters are calibrated in terms of neutron flux relative to standard manganese detectors, and an estimate of the resolving time is given. A table is included showing the working voltage and the flux required to produce a counting rate of 1 000 per minute for each counter. A.

537.542

5467. Gas discharge mechanism of halogen-quenched counters. D. VAN ZOONEN. *Appl. sci. Res. B*, **4**, *No.* 4, 237–48 (1955).

Halogen-quenched counters may be divided into two groups, I and II, comprising counters in which the ionization potential of the halogen molecules lies respectively above and below the metastable level of the rare-gas atoms. In counters of group II the ionization of halogen molecules by metastably excited rare-gas atoms and by resonance photons of the rare gas is supposed to play an important part in the multiplication. The resonance photons are absorbed and re-emitted many times before an excited rare-gas atom ionizes a halogen molecule. Experiments with two counters in one glass envelope, one with a cylinder as cathode and one with a helically wound wire as cathode, show that the photo-effect at the cathode does not play a part in the multiplication process. When one of two identical counting systems in the same bent glass envelope discharges, the other is nearly always ignited by resonance photons of the first discharge, with a delay of the order of some microseconds. The propagation of the discharge parallel to the wire in most cases appears to be faster than the lateral spread of the discharge. The region below the starting potential has been explored with an α-particle source. An ionization chamber region and a proportional region have been found. A.

537.542

5468. Some characteristics of chlorine quenched Geiger–Mueller counters. A. L. WARD AND A. D. KRUMBEIN. *Rev. sci. Instrum.*, **26**, *No.* 4, 341–51 (*April*, 1955).

Extensive studies have been made of the starting potentials and plateau characteristics of chlorine-quenched neon and argon counters with titanium and zirconium metal cathodes, using a previously described optical absorption method to measure the concentration of the halogen in the presence of the rare gases. An equation of the type first formulated by Lauterjung for the starting potentials of organic-quenched counters, has been found to hold for chlorine-quenched counters. The constants in this equation have been determined for the counter fillings and cathodes used. A nomograph has been drawn which enables the starting potentials of neon-chlorine counters to be determined for various counter dimensions, total gas pressures and percentage of chlorine. From the deviations of the experimental data from straight lines at high E/p, an estimate has been made of the behaviour of α/p (α is Townsend's first coefficient), for neon and argon at higher E/p values than those which are given in the literature. The consideration of secondary Townsend processes gives a new interpretation of the Lauterjung constants. The plateau length of counters filled to a constant total pressure was found to increase linearly with an increase in chlorine concentration. Plateau slopes have been found to decrease initially with increasing chlorine concentration, then to remain constant. Normally, it has been found to be of no advantage to add argon to a neon-chlorine counter. A.

537.542

5469. Mechanism of the termination of the Geiger plateau region. H. L. WISER AND A. D. KRUMBEIN. *Phys. Rev.*, **98**, *No.* 2, 303–10 (*April* 15, 1955).

The mechanisms responsible for the termination of the Geiger counter plateau region at its high-voltage end were investigated by a direct experimental method. Geiger counters were operated in a normal manner and counting rate *v.* voltage and number of positive ions per pulse *v.* voltage were measured in the breakdown region. Analysis of the data indicated that spurious counts could result from two phenomena: (1) Secondary electrons created by positive-ion bombardment of the cathode; and (2) Metastable atom and molecule decay in the gas. The rate of spurious counts caused by positive-ion bombardment was found to be proportional to the rate of positive ions striking the cathode and, therefore, proportional to the voltage. This accounted for the plateau slope, if present, and the slight increase in slope at the beginning of the breakdown region. It is shown that the exponential rise in counting rate in the breakdown region can be explained by the decay of metastable atoms and molecules that exist after the deadtime of the primary pulses. Experimental results indicate that metastable atoms were dominantly responsible for spurious counts at low pressures (about 40 mm Hg) and metastable molecules at high pressures (200 mm Hg). A.

537.542 : 539.185

5470. The pulse height distribution from boron trifluoride proportional counters irradiated with 4·87-MeV neutrons. D. B. JAMES, W. KUBELKA, S. A. HEIBERG AND J. B. WARREN. *Canad. J. Phys.*, **33**, *No.* 5, 219–24 (*May*, 1955).

Two boron trifluoride proportional counters, one containing normal isotopic boron and the other containing boron enriched to 96% B^{10}, have been irradiated with 4·87 MeV neutrons from the reaction $D(d, n)He^3$. In addition to the reactions $B^{10}(n, \alpha)Li^7$ and $B^{10}(n, \alpha)Li^{7*}$ with Q-values of 2·79 MeV and 2·31 MeV respectively, two other reactions have been observed. These are (i) $F^{19}(n, \alpha)N^{16*}$ with a Q-value of $-1·77 \pm 0·15$ MeV, and (ii) either $B^{10}(n, p)Be^{10}$ or, much more probably, $B^{10}(n, t)Be^8$ with a Q-value of $0·35 \pm 0·20$ MeV. Owing to the presence of these two reactions, the analysis of complex fast-neutron spectra by the use of such counters is not feasible. A.

537.542

5471. On the external cathode proportional counter. I. KUMABE AND M. SONODA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 877–8 (*Sept.–Oct.*, 1954).

Describes briefly the construction of a Maze-type counter and gives gas-multiplication-factor—voltage curves, counting Po α-particles, with a methane filling of 40 or 57 cm Hg pressure. J. D. CRAGGS

537.542

5472. Ionization chamber measurements with tritium. E. J. WILSON. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. I/M*34, 4 *pp.* (1955).

A series of tests with varying concentrations of tritium in hydrogen and at varying pressures indicate the versatility of an ionization chamber, spherical in shape, of 200 cm^3 capacity, constructed of Pyrex glass and using burnished silver, coated internally, as the electrodes. A.

537.542

5473. A pocket dosemeter, with built-in charger, for X-radiation and gamma radiation. N. WARMOLTZ AND P. P. M. SCHAMPERS. *Philips tech. Rev.*, **16**, *No.* 4, 134–9 (*Oct.*, 1954).

Following a brief recapitulation of the effects of ionizing radiations upon biological tissue, the principles of dosimetry, tolerance dosages and the effects of intense irradiation are considered. After descriptions of existing types of pocket dosemeter a more detailed account is given of a new design which incorporates a self-charger and which dispenses with a microscope. This instrument is fully enclosed in a vacuum-tight bulb of conductive glass, which, in turn, is housed in an aluminium case. Full-scale deflections corresponding to dosages of 0·2 r, 70 r, 250 r, or more, can be obtained by adopting suitable dimensions for the instrument and by varying the gas pressure. The discharge in the absence of radiation is considerably less than 1% per 24 hours. The charger is a glass tube containing a drop of mercury, which during the charging process, is connected to the sensitive system by means of a magnetic switch. Charging is effected by shaking the instrument several times, with the electrometer system facing downwards. Attention also is drawn to the suitability of the individual electroscope and charger systems for demonstration purposes. A.

537.542

5474. Plate separation required for standard free-air ionization chambers. F. H. ATTIX AND L. DELA VERGNE. *Radiology*, **63**, *No.* 6, 853–66 (*Dec.*, 1954).

A free-air "grid" chamber is described, having plate separation of 28 cm. Two parallel grids of graphited Nylon thread are placed near the collector plate. Between the collimated X-ray beam and these grids is a removable "electron filter" of graphited polystyrene, electrically grounded. This stops all electrons approaching the grids but allows scattered photons to pass. Three experiments for each X-ray energy are performed: (1) determination by means of the grids of ionization produced in 1 cm thick parallel layers of air at perpendicular distances from the collimated beam; (2) repeat of (1) with the "electron filter" interposed and calculation of ionization for only electrons originating in the beam; (3) measurement of ionization in a conventional free-air chamber to allow expression of previous readings as fractions of the whole ionization. Construction and use of the chamber are described in detail. A vibrating reed electrometer is used. Electron ionization losses caused by insufficient plate separation are given for separations up to 28 cm for X-rays of 60–250 kV. Results of previous workers are discussed and compared. D. V. MABBS

537.542

5475. ZnS(Ag) phosphor mixtures for neutron scintillation counting. P. G. KOONTZ, G. R. KEEPIN AND J. E. ASHLEY. *Rev. sci. Instrum.*, **26**, *No.* 4, 352–6 (*April*, 1955).

Selected compounds of hydrogen, lithium, boron and fissionable elements were mixed in varying proportions with ZnS(Ag), and the corresponding neutron and γ-counting efficiencies measured as functions of energy. The low sensitivity of these mixtures to γ (10^{-5}–10^{-4}%) and the measured short time decay constant ($\tau = 0{\cdot}04\mu$sec) offer distinct advantages for fast neutron counting. A.

537.542

5476. End-window radioactivity in photomultipliers. A. G. HESTER. Letter in *J. sci. Instrum.*, **32**, *No.* 4, 154–5 (*April*, 1955).

Detailed experiments show that background counts occur in photomultipliers due to radioactivity in the cathode window if the latter contains potassium.

G. F. J. GARLICK

537.542 : 539.166.08

5477. The pulse height distribution from a sodium iodide single crystal scintillation counter and the measurement of gamma ray fluxes. G. M. GRIFFITHS. *Canad. J. Phys.*, **33**, *No.* 5, 209–18 (*May*, 1955).

The theory of the interaction of γ-rays with a single crystal of sodium iodide is described and a comparison made between the pulse height distributions, calculated on the basis of primary interactions only, together with the broadening due to the statistics of light production and electron multiplication, and the experimentally measured distributions. The differences are qualitatively accounted for on the basis of secondary interactions, bremsstrahlung, and wall effects. The absolute efficiency of a scintillation counter, calculated from the size and volume and energy corresponding to the bias level of the counting system, has been used to compute the intensity of γ-radiation from a standardized source of Co^{60} and from the reaction $Li^7(p,\gamma)Be^8$, the yield of which was known from previous work. Good agreement was obtained after allowance was made, experimentally, for the secondary interactions. A.

537.542 : 519.2

5478. The statistics of the adjustment and comparison of counters. K. D. OUTTERIDGE. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. I/M*32, 7 *pp.* (1954).

A theoretical justification is given for a criterion which has been proposed by other workers for comparing different counters, and for determining the optimum values of the variable parameters (e.h.t. value, etc.) of a single counter. The application and validity of this criterion are discussed

with reference to the adjustment of a γ-scintillation counter, and to the comparison of a proportional counter with a G.M. counter for counting low-energy β-particles. A.

537.543 : 621.385.2

5479. Electron temperature in the parallel plane diode. T. N. CHIN. *J. appl. Phys.*, **26**, *No.* 4, 418–23 (*April*, 1955).

Chandrasekhar's relaxation time is applied to the electron gas in flow. By determining the relaxation time, t_R, and the mean transit time, t_T, two types of electron flow may be characterized: anisotropic flow if $t_T \ll t_R$, and isotropic flow if $t_R \ll t_T$. It is shown that the electron temperature along the flow decreases as the mean velocity of the electrons increases in a parallel-plane diode. In the given examples, the boundary conditions are obtained for a particular model which has been recommended in the study of thermionic emission. A.

IONIZATION . THERMIONICS 537.56/.58

537.561

5480. Selected positive and negative ions in the mass spectra of the monohalomethanes. V. H. DIBELER AND R. M. REESE. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 3, 127–34 (*March*, 1955).

Ionization potentials of the molecule ions and appearance potentials of the methyl and halogen positive ions and of the halogen negative ions have been measured for CH_3F, CH_3Cl, CH_3Br and CH_3I and compared with previously reported spectroscopic and electron-impact data. A value is obtained for the ionization potential of HF by graphical comparison of the ionization potentials of the hydrogen and methyl halides. Carbon-halogen bond-dissociation energies are computed from appearance potentials of the methyl ion and of the halogen ion. A simple relation between bond-dissociation energy and bond distance is observed for the methyl halides. A.

537.564

5481. Dissociation by impacts of the second kind. W. E. GROTH AND O. OLDENBERG. *J. chem. Phys.*, **23**, *No.* 4, 729–31 (*April*, 1955).

The process by which an excited Kr atom in an impact of the second kind dissociates an N_2 molecule is investigated by comparison with related processes. (1) The production of free N atoms is not due to an atom transfer reaction. (2) It is not due to the "resonance" transfer of electronic energy of Kr′ directly into vibrational energy of N_2 leading to dissociation. (3) It is due to the transfer of electronic energy of Kr′ into electronic energy of N_2. The simplest interpretation is the production of a repulsive level of N_2 which immediately dissociates. A.

537.564

5482. The Layzer approximation for the treatment of collisions of electrons with atoms. U. ÖPIK. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 377–84 (*May*, 1955).

A new approximation, proposed by Layzer [Abstr. 1863 (1952)], is investigated theoretically and applied to the excitation by electron impact of the 2^2S and 2^2P levels of hydrogen (the latter level only in the case of a reversal of the spin of the atomic electron) and of the $1s2s^1S$, $1s2s^3S$ and $1s2p^3P$ levels of helium. The cross-sections are evaluated for a number of incident electron energies. The theoretical basis of the approximation is shown to be unsatisfactory. In the case of the final states being S states, a comparison of the cross-sections calculated by the new method with those obtained by other methods suggests that, for slow incident electrons, most of them may be expected not to differ by more than a factor of about two from the true cross-sections. However, the 1^2S–2^2S cross-section of hydrogen associated with an antisymmetrical spatial wave-function for the electrons seems to be too large by a greater factor. No reliable comparison data are at present available for the S–P transitions, but the results do not seem unreasonable. The approximation is shown to give correctly the asymptotic variation of the non-exchange cross-sections for large incident electron energies, but not the numerical coefficients. The pure exchange S–P cross-sections fall off too slowly with increasing incident energy. In spite of the theoretical defects, there is some hope that the new approximation may prove useful, at least as an empirical method. A.

537.564

5483. The break-up of negative ions in the cyclotron. J. H. FREMLIN AND V. M. SPIERS. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 398–403 (*May*, 1955).

A pinhole camera at the periphery of the cyclotron was used to record neutral products of dissociation of molecular ions accelerated to various radii. From the numbers of particles reaching different parts of a C2 nuclear plate in the camera, the attenuation of the accelerated ions due to collisions with residual air molecules should be deduced. This was compared with the attenuation of H_2^+ ions observed in a similar way. The cross-section for dissociation of these by air is known, so the cross-sections for other ions could be determined. At a velocity corresponding to 1 MeV per nucleon, the cross-sections for D^- and HeH^+ were found to be respectively $7{\cdot}6\times10^{-16}$ cm^2 and $1{\cdot}0\times10^{-14}$ cm^2 with an accuracy to about 30%. A.

537.583 : 548.7

5484. Electron emission and colour centres in ionic crystals. A. BOHUN. *Czech. J. Phys.*, **5**, *No.* 1, 64–79 (*Feb.*, 1955) In German.

Thermionic emission of electrons from photochemically and additively coloured NaCl crystals is studied with respect to temperature and dependence on F-band bleaching. Photoelectric emission for the latter is also measured. Correlation of thermionic-emission temperature curves with colour-centre characteristics is obtained. See also Abstr. 4833 (1953). G. F. J. GARLICK

537.583 : 621.385.032.21

5485. A new type of diffusion cathode. A. H. BECK, A. D. BRISBANE, A. B. CUTTING AND G. KING. *Vide*, **9**, 302–9 (*Nov.*, 1954) In French and English.

The cathode described, together with its properties, combines some of the features of the Ba aluminate cathodes and of the moulded cathodes, in that it may

consist of a homogeneous mass of active material, as does the Ba aluminate cathode, but has, as basic material, mixtures of alkaline-earth carbonates and Fe, Ni, or Co powder with addition of suitable reducing agents. The mixed powders are compacted at high pressures, usually into metallic retaining cylinders for simplified handling. During decomposition of the alkaline earth carbonates to oxides and alkaline-earth metal, the Ni sinters into a strong metallic matrix. Several possible forms of cathode are illustrated and they are named bariated nickel or B–N cathodes. Good service has been given in reflex klystrons and television picture tubes. Eight figures and 7 references are given. H. H. HODGSON

537.583 : 621.385.032.21

5486. Preliminary investigations on moulded cathodes based on barium salts. H. HUBER AND J. FREYTAG. *Vide*, **9**, 310–16 (*Nov.*, 1954) In French.

The physico-chemical properties of reservoir cathodes of the type Ba–W and of known emissive mixtures are reviewed. The results demonstrate the utility of such cathodes for tubes for which high-density currents have a dominant rôle. The influence of the sintering operation is shown to be an important factor for the efficiency of the barium deposit. Seven figures and 28 references. H. H. HODGSON

537.583 : 621.385.032.216

5487. The effect of positive ion bombardment on the oxide cathode. K. TAKEYA, T. SHIRAKAWA AND S. TAKAHASHI. *Vide*, **9**, 116–20 (*July–Sept.*, 1954) In French and English.

Cathodes were bombarded in air, CO_2 and argon with energies between 40 and 4000 V. When the activity was initially good, the bombardment reduced it but when poor it was sometimes improved. By locating a W emitter in front of the cathode it was shown that Ba was sputtered off the latter.

A. H. W. BECK

537.583 : 621.385.032.216

5488. The migration of impurities to the nickel/oxide interface in oxide cathodes. G. A. GIGER. *Vide*, **9**, 125–8 (*July–Sept.*, 1954) In French.

Tubes were operated for e.g. 1000 hr and a chemical analysis was made of the interface. The major result was the marked increase in Si content. After 1000 hr a nickel with 0·45% Si initially, showed 0·97% at the interface, while one with 0·015% increased to 0·128%. Measurements of interface resistance showed a strong correlation between this and Si content, but not with Fe or Mg content.

A. H. W. BECK

537.583 : 621.385.032.216

5489. Evaporation of barium with metallic capillary cathodes. H. KATZ. *Vide*, **9**, 279–83 (*Nov.*, 1954) In French and German.

The disadvantages of Ba evaporation when using capillary cathodes are discussed, and devices to reduce this defect are considered. In rectifiers filled with an inert gas (e.g. argon), evaporation appears to be inhibited, but *in vacuo*, and with a W–$BaCO_3$–Si cathode, various cases occur according to the porosity acquired by the frit during the sintering operation. Suitable cathodes are proposed based on these porosity data. H. H. HODGSON

537.583 : 621.385.032.216

5490. The impregnated cathode and its structural characteristic as compared with the L cathode. R. LEVI. *Vide*, **9**, 284–9 (*Nov.*, 1954) In French and English.

The useful properties of the dispenser-type thermionic L cathode are listed, its drawbacks discussed, and the improved Phillips impregnated cathode described. The L cathode consists of a molybdenum tube divided into 2 chambers, the lower containing the heater and the upper a tablet of (Ba–Sr)CO_3. A porous tungsten disk is welded on top of the Ba reservoir, so that the only connection with the outside from the upper chamber is through the pores of the tungsten disk. In the new design, the alkaline earth material is a mixture of normal and basic Ba aluminates which is dispersed throughout the pores of the tungsten body, thus eliminating the need for a large cavity reservoir. The advantages claimed are: (1) elimination of the need for a gas-tight weld; (2) extreme simplification in cathode construction; (3) part extension of the possible sizes and shapes that can be fabricated; (4) more homogeneous temperature distribution across the emitting area; (5) improved thermal efficiency; (6) more space for the heater, thus permitting the use of larger heaters; (7) reduced period of pumping. Interest in the new cathode is at present concentrated in the magnetron, klystron and travelling-wave-tube fields. Seven figures and 6 references are given. H. H. HODGSON

537.583 : 621.385.032.216

5491. Thermionic properties of moulded cathodes made of metals and alkaline earth oxides. R. UZAN. *Vide*, **9**, 290–6 (*Nov.*, 1954) In French.

Describes the four stages of the preparation of thermionic cathodes from homogeneous mixtures of metallic powders of metals and alkaline earths, namely, mixing, compression, frit formation, and mounting in the tubes. An account follows of investigations of Ni and W cathodes, obtained respectively from the metallic powders (8 atoms) with $BaCO_3$–$SrCO_3$ (2 molecules) and fritted at 1100°C, with regard to activation, performance, influence of frittage temperature, and variation of cathode composition. Twelve figures and 4 references are given.

H. H. HODGSON

537.583 : 621.385.032.216

5492. Direct-emission thermionic fritted [sintered] cathodes. T. C. NGUYEN AND P. DUSSAUSSOY. *Vide*, **9**, 297–301 (*Nov.*, 1954) In French.

A new M cathode is described which is made by cold compression of a mixture of Ni powder and alkaline earth carbonates into a cylindrical block or parallelepiped, which is then fritted in a protective atmosphere (e.g. in hydrogen, at 950–1050°C, for 1 hour), and, when subsequently heated, is a useful source of electrons. These M cathodes are now studied with respect to increase of carbonate reserve and emissive surface, and the adherence of the active layer to the metallic base. Experimental data are given for diodes and for magnetrons. Twelve figures.

H. H. HODGSON

537.583 : 621.385.032.216 : 621.317.39

5493. An oscillographic method for measuring work function as a function of temperature. C. G. J. JANSEN, R. LOOSJES, J. J. ZAALBERG VAN ZALST AND G. A. ELINGS. *Vide*, **9**, 135–8 (*July–Sept.*, 1954) In French.

Describes an oscillographic technique in which i_{sat} is measured as a function of T with constant anode voltage. The time of a measurement is only about 10 sec and T is measured by a thermocouple. Poisoning is eliminated and it is also possible to determine $d\phi/dT$ from curves of i_{sat} as a function of T calculated from the Richardson formula. A. H. W. BECK

COSMIC RAYS 537.591

537.591

5494. Measurements on cosmic-ray protons. C. BACCALIN, P. BASSI AND C. MANDUCHI. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 657–68 (*April*, 1955) In Italian.

A "heavy particle selector" with a Cherenkov counter in anticoincidence has been used to measure the absolute intensity, the zenith angle distribution, the barometric effect and the altitude variation of cosmic-ray protons around 400 MeV energy. Measurements have also been made of the neutron to proton ratio in the same energy region, and the anelastic nuclear interaction length in C and Pb for protons. With the exception of the neutron proton ratio, all the results are consistent with the theoretical description of the nucleon cascade in the atmosphere. A.

537.591.15

5495. The second maxima in the transition curve of cosmic ray showers. J. B. HARDING AND P. R. ROBINSON. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. N/R*1550, 13 *pp.* (1954).

Four trays of G.M. counters, separated by a lead absorber were arranged to detect showers produced by charged particles. Slight indications of an extended secondary maximum in the transition curve disappeared when the apparatus was lifted well above the floor. An explanation is presented. This work is compared with that of observers who have presented evidence for a sharp secondary maximum. An explanation of the disagreement can only be obtained in terms of an unknown particle with unusual properties. Such an hypothesis must therefore be regarded as very tentative. A.

537.591.15

5496. On the collision of fast nucleons with nuclei. E. L. FEINBERG. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 241–2 (1955) In Russian.

In the collision of fast nucleons and mesons ($\sim 10^{10}$–10^{12} eV) the usual picture of successive collisions with individual nucleons is shown to be incorrect in some specific cases. G. E. BROWN

537.591.15

5497. The lateral distribution of various components in extensive air showers at sea level. G. FUJIOKA. *J. Phys. Soc. Japan*, **10**, *No.* 4, 245–9 (*April*, 1955).

The lateral distribution of electrons, μ-mesons and N-components are observed at sea level up to 50 m from the core. The distribution of electrons is consistent with that calculated on the basis of cascade theory. The distribution of μ-mesons is flatter than that of electrons and is represented as $r^{-0.7}$. The distribution of N-components is similar to that of electrons. The number of μ-mesons is equal to that of N-components at several metres from the core. A.

537.591.15 : 537.542

5498. A cosmic-ray shower selecting circuit. A. SUBRAMANIAM. Letter in *J. sci. industr. Res.*, **14B**, *No.* 2, 85–6 (*Feb.*, 1955).

Details are given of this circuit which detects a minimum number of coincident discharges in a tray of counters, where the counters are all connected in parallel, together with the simultaneous discharge of counters in other trays. P. ROTHWELL

537.591.2

5499. Measurements of the momentum spectrum of μ-mesons at sea level. I. The momentum range 5×10^8 eV/c–2×10^{10} eV/c. B. G. OWEN AND J. G. WILSON. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 409–18 (*May*, 1955).

The μ-meson momentum spectrum near sea level in 57°N geomagnetic latitude has been measured for strictly defined angles of collection near the vertical direction. Results are given, covering the momentum range 5×10^8 eV/c$<p<2\times10^{10}$ eV/c which are based on the measurement of about 60 000 trajectories. A.

537.591.3

5500. On anomalies in the absorption of cosmic rays in lead. G. L. KEECH AND F. GULBIS. Letter in *Canad. J. Phys.*, **33**, *No.* 3–4, 148–9 (*March–April*, 1955).

The absorption in lead was investigated using counter telescopes and it is concluded that there is no anomaly greater than 1% in the absorption curve up to a thickness of 45 cm. H. ELLIOT

537.591.5

5501. East–West asymmetry at 48°N of geomagnetic latitude. P. CHALOUPKA AND J. PERNEGR. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 91–2 (*Feb.*, 1955) In Russian.

Although measured by a number of experimenters figures for the E–W asymmetry in higher latitudes for the arriving primary cosmic-ray particles differ markedly. The authors have carried out measurements of the distribution of particles in various directions on the Lomnitsky Peak at 2640 m above sea level and 48°N geomagnetic latitude. A conventional telescope arrangement with G.M. counters and lead plate absorbers was used, the whole equipment being able to turn about vertical and horizontal axes. To date only dependence of intensity of particles upon zenith angle in the E–W plane has been measured. Asymmetry is estimated at $(3{\cdot}6 \pm 1{\cdot}8)\%$. C. R. S. MANDERS

537.591.8

5502. Star disintegration in the emulsions of nuclear plates. L. TOMÁŠKOVÁ. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 87–8 (*Feb.*, 1955).

Gives experimental results on the frequency of stars observed in emulsions under various thicknesses of lead. Two maxima are found, one at 2 cm and another at 22–24 cm. H. ELLIOT

537.591.8

5503. Distribution of stars caused by cosmic rays in nuclear emulsions. M. Voříšek. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 89–90 (*Feb.*, 1955) In Russian.

During exposure of nuclear plates disintegrations of nuclei of the emulsion may occur singly, or connected in pairs or greater numbers. Assuming a uniform distribution of stars in a plane of the emulsion the authors have derived by a different method from Davis, *et al.* [Abstr. 310 (1953)] an expression for the expected number of pairs at distance $\leqslant r$ from one another, viz.

$$P(r,N,S)=\tfrac{1}{2}N^2r^2/s^2\{\pi ab+r^2(16/3-4\pi)-4/3\,(a+b)r\}$$

where $S = ab$, area of plate of sides a and b, N = No. of stars. If the actual measured number of stars is denoted by $Q(r, N, S)$ then $E = Q - P$ indicates to what degree the disintegration of pairs is uniform or not. Plates (Ilford C2) were exposed for 42 days in vertical position on Lomnitsky Peak at 2640 m above sea level. Dependence of E upon r was measured from 0 to 2 mm at intervals of 200 μ; maxima occur at 600 μ and 1400 μ which are not explainable in terms of the hypothesis of Leprince–Ringuet and co-workers [Abstr. 2879 (1948)].

C. R. S. MANDERS

537.591.8

5504. On the nuclear interaction of He-nuclei in the cosmic radiation. M. Ceccarelli, G. Quareni and G. T. Zorn. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 669–78 (*April*, 1955).

Forty-two stars, produced in photographic emulsions by the nuclear interaction of cosmic-ray He nuclei have been identified. They were selected in a systematic way, based on the identification of the tracks associated with nuclear disintegrations. These disintegrations, as well as those produced by "primary" protons in the same plates were analysed, and the angular and frequency distributions for both types of stars were determined. From a comparison of these distributions it has been concluded that, on the average, only about one-half of the nucleons of the He nucleus contribute appreciably to the destruction of the target nucleus and to the production of mesons. A.

537.591.8 : 539.17

5505. An atlas of typical expansion chamber photographs. W. Gentner, H. Maier-Leibnitz and W. Bothe. *London: Pergamon Press* (1954) x + 199 *pp.*, *with* 194 *plates.*

Review in *J. atmos. terrest. Phys.*, **6**, *No.* 4, 231–2 (*April*, 1955).

MAGNETISM 538

538.082 : 538.652

5506. Apparatus for the measurement of magnetostriction by means of a variable capacity. K. Wotruba. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 102–3 (*Feb.*, 1955) In German.

A schematic description of an apparatus of the electrical ultramicrometer type, arranged so as to allow the actual length of the specimen, as well as changes in length, to be measured. The sensitivity quoted is 1700 c/s per micron, and a short period stability of 15 c/s is claimed. A. E. DE BARR

538.082 : 550.38 : 621.317.444

5507. A simple, sensitive, saturated-core recording magnetometer. V. B. Gerard. *J. sci. Instrum.*, **32**, *No.* 5, 164–6 (*May*, 1955).

A versatile saturated-core recording magnetometer, designed to meet a number of geophysical uses, is described. Comparisons with a standard magnetic observatory variometer show that the large amount of negative feedback used keeps the instrument very stable. It has good h.f. response, and is simple to manufacture and service. A.

538.082.1

5508. An automatic recording torsional magnetic susceptibility balance. G. T. Croft, F. J. Donahoe and W. F. Love. *Rev. sci. Instrum.*, **26**, *No.* 4, 360–3 (*April*, 1955).

A torsional magnetic susceptibility balance suitable for studying the de Haas–van Alphen effect has been developed in which the torque and magnetic field are recorded continuously while the magnet current is reduced automatically. The torque is recorded as a bucking current to a galvanometer suspension supporting the sample, and the magnetic field is obtained from a recording of the magnet current. A circuit for stabilizing the magnet current is also described. A.

538.114

5509. Interaction between spin waves and conduction electrons in ferromagnetic metals. E. Abrahams. *Phys. Rev.*, **98**, *No.* 2, 387–90 (*April* 15, 1955).

With a view toward understanding ferromagnetic resonance line widths in metals, the relaxation time due to the spin wave–conduction electron interaction has been calculated. The effect due to the interaction of ferromagnetic spins with conduction electron currents is much more important than that due to the interaction of ferromagnetic spins with conduction electron spins. In nickel, for temperatures between 4°K and 300°K, the former process yields a relaxation time 10^{-8}–10^{-7} sec, while the latter yields 10^{-3}–10^{-4} sec. The interactions do not appear to be strong enough to account for the observed line widths. A.

538.22 : 537.311.33

5510. Magnetic susceptibility measurements on germanium between room temperature and liquid hydrogen temperatures. A. van Itterbeek, L. de Greve and W. Duchateau. *Appl. sci. Res. B*, **4**, *No.* 4, 300–8 (1955).

Susceptibility measurements have been done on germanium samples with different degrees of impurities. The susceptibilities from room temperature down to liquid hydrogen temperatures were measured. The results have been compared with those of Stevens and Crawford who also measured susceptibilities of germanium samples, but only down to liquid nitrogen temperatures. At liquid hydrogen temperatures a strong variation of the susceptibility was noticed, which is a consequence of the paramagnetic term, as predicted by Busch and Mooser from their measurements on α-tin. A.

538.221

5511. On the magnetic ageing of [commercially] pure iron. M. ASANUMA AND S. OGAWA. Note in *J. Phys. Soc. Japan*, **10**, *No.* 2, 161 (*Feb.*, 1955).

Describes experiments to show that the decrease of the initial susceptibility of iron on tempering near 130°C is mainly due to the precipitation of nitrogen, artificially introduced after annealing the specimen in an atmosphere of hydrogen. The presence of sulphur and carbon impurities was found to have little effect. E. P. WOHLFARTH

538.221

5512. Magnetic rotation phenomena in a polycrystalline ferrite. II. D. PARK. *Phys. Rev.*, **98**, *No.* 2, 438–41 (*April* 15, 1955).

The calculations of Pt I [Abstr. 1991 (1955)] are extended to the determination of the entire permeability tensor of a polycrystalline sample of a ferrimagnetic material in which there is a slight over-all magnetization. The calculation takes account of the largely random orientation of the magnetic axes of the crystallites and of the fact that their characteristic resonant frequencies are statistically distributed. It is shown that the magnetic interaction between crystallites can be included, but it does not greatly affect the form of the final results. A.

538.221

5513. Direct observation of domain rotation in ferrites. F. BROWN AND C. L. GRAVEL. *Phys. Rev.*, **98**, *No.* 2, 442–8 (*April* 15, 1955).

A direct experimental observation of domain rotation in the initial permeability region of sintered nickel ferrite has been made using a technique similar to that originated by F. Bloch to observe nuclear precession. A 5 mm diameter sphere of ferrite is surrounded by crossed transmitter and receiver loops adjusted for minimum r.f. signal when the sample is demagnetized. Application of an external steady field (as low as 5 Oe, perpendicular to both loops) then causes a measurable receiver loop output which cannot be eliminated by readjusting the planes of the loops. The motion of the net magnetic moment is thus rotational. In the present case, the external field is needed only to polarize the sphere, the field for Larmor precession being supplied by the equivalent anisotropy fields seen by each individual domain. Since the applied field is much smaller than these anisotropy fields, a plot of the detector loop output (per unit applied field) *v.* frequency delineates the rotational resonance spectrum of the polycrystalline sample. Measurements have been made from 20 Mc/s to 800 Mc/s and can be described qualitatively using the theory of domain rotation. In order to understand the relatively low dispersion frequency indicated by the measurements, it is hypothesized that intermediate conditions exist in some polycrystalline ferrites between the situation in which the initial permeability is purely a result of domain rotation and that in which motion of domain walls is the dominant mechanism. The distinction between the models is thus probably not very sharp. A.

538.221 : 538.566 : 621.318.1 : 621.374.3

5514. Time delay in high-speed ferrite microwave switches. R. C. LECRAW AND H. B. BRUNS. Letter in *J. appl. Phys.*, **26**, *No.* 1, 124 (*Jan.*, 1955).

See Abstr. 9387 (1954). The results of further investigations into the actual value of the time delay which must necessarily exist are described. The length of the ferrite rod required for switching, i.e. for 90° rotation, is 3 in. Plots are shown of magnetizing current and flux derivative *v.* time and of time delay and relative amplitude of ϕ_{max} *v.* distance from the centre of the rod, where the narrow switching coil is located. From immediate observation the switching time delay is clearly $>5\,m\mu sec$. As, however, the magnetization at the centre is greater than that at the ends, the actual switching time delay is calculated to be $3{\cdot}2\,m\mu sec$. H. G. M. SPRATT (R)

538.221 : 548.7

5515. Ferromagnetic domain patterns on single crystals and bicrystals of nickel. U. M. MARTIUS AND K. V. GOW. *Canad. J. Phys.*, **33**, *No.* 5, 225–34 (*May*, 1955).

Ferromagnetic domain patterns were studied on the (110), (112) and (001) planes of single crystals of nickel. The crystals were grown from seeds of predetermined orientation and no mechanical cutting was required prior to the observation of the domain patterns. The results are compared with data in the literature, existing discrepancies are pointed out and interpreted. The influence of grain boundaries on the domain patterns is shown in experiments with bicrystals. A.

538.222

5516. Paramagnetic resonance in different forms of carbon. J. E. BENNETT, D. J. E. INGRAM AND J. G. TAPLEY. *Defects in crystalline solids* [*Bristol*] 65–73. See Abstr. 5707 (1955).

Measurements are reported on paramagnetic absorption lines observed in several different kinds of carbon, and the results suggest that this effect is probably due to the free valence bonds at the ends of polymer chains, or at discontinuities in the structure. Results on the pure carbon samples show that only those of a porous, charcoal nature give the narrow absorption line, and conversion of these to a more gritty, graphitic type of structure eliminates the signal. Measurements on the residues of charred diamagnetic organic salts show several additional features, including a variation of line width with the different diamagnetic atoms present, and also provide evidence for a second type of absorption, which may be connected with the electron carriers in the finely dispersed metal particles. Finally, the presence of very wide absorption lines in lead–carbon solid solutions is reported, and, although these may be due to ferromagnetic impurity, the results seem to suggest that an interaction between the electron carriers in the lead and carbon is responsible for it. A.

538.222

5517. Paramagnetic resonance in sodium and potassium superoxides. J. E. BENNETT, D. J. E. INGRAM, M. C. R. SYMONS, P. GEORGE AND J. S. GRIFFITH. Letter in *Phil. Mag.*, **46**, 443–4 (*April*, 1955).

Describes measurements on NaO_2 and KO_2 at 90°K and at frequencies 9, 23 and 36 kMc/s. The

g-values observed were $g_{\|} = 2{\cdot}175$, $g_{\perp} = 2{\cdot}002$. The results are interpreted in terms of the energy-level structure of the O_2^- ions whose presence gives rise to the resonance phenomenon. E. P. WOHLFARTH

538.222

5518. The paramagnetic resonance spectra of some rare-earth double nitrates. A. H. COOKE AND H. J. DUFFUS. *Proc. Roy. Soc. A*, **229**, 407–15 (*May* 10, 1955).

The paramagnetic resonance spectra of praseodymium magnesium nitrate, neodymium magnesium nitrate and samarium magnesium nitrate have been analysed using centimetre wavelengths. The spectra were observable only on cooling the crystals to 4·2°K; at higher temperatures the spin-lattice relaxation times were so short as to broaden the lines beyond the possibility of detection. The spectroscopic splitting factors (g-values) and hyperfine structures exhibit great anisotropy. The values of the nuclear spins of Sm^{147} and Sm^{149} are both confirmed to be $\frac{7}{2}$. The magnetic susceptibility and the magnetic contributions to the specific heat are computed for each salt. In each case the nuclear hyperfine structure is responsible for the principal contribution to the specific heat. A.

538.222 : 535.371

5519. Paramagnetic resonance spectrum of some doubly activated phosphors. W. LOW. *Phys. Rev.*, **98**, *No.* 2, 426–31 (*April* 15, 1955).

The paramagnetic resonance spectra of four different infrared stimulable strontium sulphide phosphors have been investigated. The hyperfine spectrum in SrS : Eu, Sm phosphor confirms the existence of divalent europium. The quantum efficiency in this phosphor is less than 1 photon per 10 europium activators. The ground state of europium is split by $0{\cdot}18\,cm^{-1}$ because of spin-orbit coupling in a cubic field. The manganese spectrum in a solid solution of strontium sulphide and selenide is discussed. A.

538.24

5520. The heat changes accompanying magnetization processes in ferrites. L. F. BATES AND N. P. R. SHERRY. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 5, 304–9 (*May*, 1955).

Measurements have been made, for the first time, of the thermal changes accompanying the step-by-step magnetization of a number of ferrites. The method was that used with metals by Bates and his co-workers, with the added improvement that the thermal deflections were recorded *via* a split photocell amplifier. Measurements were made on certain mixed ferrites of the nickel–zinc series. The results showed that the major part of the heat changes can be explained satisfactorily in terms of the changes of intrinsic magnetization with field. In some of the specimens a slight irreversible heating was observed; it therefore appears that domain rotational effects make a very small contribution to the thermal changes. An anomalous, low field effect previously found in certain metals occurred in some of the ferrites. This effect is not yet fully understood, although some qualitative suggestions are made to account for it; it is concluded that the observed thermal effects in ferrites can be explained on the same lines as those for metals. A.

538.27 : 538.632

5521. Hall effect in cesium antimonide with audio-frequency currents. T. SAKATA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 6, 1030–1 (*Nov.–Dec.*, 1954).

The magnitude and phase of the Hall effect measured at 800 c/s between 189 and 357°K is reported for several samples. The Hall value of energy gap is ~0·5 eV, the hole mobility $6 \sim 11\,cm^2\,volt^{-1}\,sec^{-1}$, and the mean free path $4 \sim 7 \times 10^{-8}$ cm. The Hall mobility varies as $T^{-3/2}$. C. A. HOGARTH

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3

5522. The resolution of four-dimensional vector fields and tensor fields, and its application to electrodynamics. N. L. BALAZS. *Canad. J. Phys.*, **33**, *No.* 5, 235–40 (*May*, 1955).

Helmholtz's theorem is generalized and applied to four-dimensional vector fields and tensor fields. For vector fields the generalization is straightforward. Antisymmetric tensor fields of rank two exhibit a beautiful symmetry between the irrotational part of the tensor and the dual of the solenoidal component. The physical applications show that in Maxwell's theory the irrotational part of the four-potential field has no physical meaning and the Lorentz condition makes it identically zero. In Dirac's new electrodynamics an algebraic condition is imposed on the four-potential. Hence in this theory the irrotational part is not zero, and the algebraic condition establishes a relation between the sources and vortices of the four-potential field. If the resolution is applied to the electromagnetic field tensor it can be seen that the free charges are responsible for the sources, and the magnetic poles, if they exist, for the vortices, provided the customary association between the components of the electromagnetic field tensor and the components of the electric and magnetic fields is used. A.

538.3 : 532.517.4

The decay of magneto-turbulence in the presence of a magnetic field and Coriolis force. *See Abstr.* 5249

538.3 : 532.517.4

Magneto-hydrodynamics on cosmical and laboratory scale. *See Abstr.* 5250

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.56 : 534.222.2

5523. Stationary magnetohydrodynamic shock waves of arbitrary strength. R. LÜST. *Z. Naturforsch.*, **10a**, *No.* 2, 125–35 (1955) In German.

A continuation of previous work [Abstr. 8583 (1953)] in which the refraction of magnetic lines of

force and the changes in density and pressure at a plane shock front are investigated for a plasma of infinite conductivity. Three different types of waves are shown to exist; in the limiting case of weak shock, one type of waves degenerates into an Alfvén wave and the others to sound waves. R. A. NEWING

538.56 : 537.311.33 : 548.7

5524. Propagation and plasma oscillation in semiconductors with magnetic fields. B. LAX AND L. M. ROTH. Letter in *Phys. Rev.*, **98**, *No.* 2, 548–9 (*April* 15, 1955).

An analysis of the effects of fields on the energy-band structures of crystals. The results may be used, for example, to investigate the shapes of energy bands in anisotropic semiconductors at microwave frequencies. C. A. HOGARTH

538.566

5525. Scattering of a plane wave from a circular dielectric cylinder at oblique incidence. J. R. WAIT. *Canad. J. Phys.*, **33**, *No.* 5, 189–95 (*May*, 1955).

A solution is given for the problem of a plane wave incident obliquely on a circular cylinder of infinite length. The electric properties of the cylinder are taken to be homogeneous and isotropic but otherwise arbitrary. It is shown that in the general case the scattered field contains a significant cross-polarized component which vanishes at normal incidence. While the solution is derived for the magnetic vector of the incident wave transverse to the axis of the cylinder, the corresponding result for the other polarization can be obtained from symmetry. A.

538.566

5526. Diffraction of electromagnetic waves by circular plate and circular hole. Y. NOMURA AND S. KATSURA. *J. Phys. Soc. Japan*, **10**, *No.* 4, 285–304 (*April*, 1955).

Rigorous solutions are presented of the problems of diffraction of plane electromagnetic waves by an infinitely thin, perfectly conducting, circular disk and by a circular hole in a plane conducting screen. The unique solution satisfying the edge condition is obtained from the two-component Hertz vector, by the method of expansion in the hypergeometric polynomial. Total scattering cross-section, the transmission coefficient, electric current on the disk, electric field in the hole, and electric field at the distant place are shown in the figure as a function of $ka = 2\pi a/\lambda$. A.

538.566

5527. Diffraction of electromagnetic waves by a metallic wedge of acute dihedral angle. W. W. GRANNEMANN AND R. B. WATSON. *J. appl. Phys.*, **26**, *No.* 4, 392–3 (*April*, 1955).

In the rigorous theory of diffraction by a conducting wedge as developed by Sommerfeld and extended by Pauli, the total field is represented by the terms given by geometrical optics plus a contour integral which represents the diffracted waves. If the faces of the wedge form a dihedral angle of π/m, $m = 1, 2, 3 \ldots$ the contour integral vanishes identically and the solution given by geometrical optics is exact. This prediction has been tested and checked by measurements and calculations of the diffraction patterns of wedges whose dihedral angles were 90° and 30°. The measurements were made at a wavelength of 1·25 cm. A.

538.566 : 534.222.2

Measurement of detonation velocity by Doppler effect at three-centimeter wavelength. *See Abstr.* 5278

538.566 : 621.396.11

5528. Studies of the diffraction of electromagnetic waves by circular apertures and complementary obstacles: the near-zone field. M. J. EHRLICH, S. SILVER AND G. HELD. *J. appl. Phys.*, **26**, *No.* 3, 336–45 (*March*, 1955).

Techniques for measuring both the electric and magnetic field distributions are presented and the general experimental problems are discussed. Data are given for the tangential components of the electric and magnetic vectors in the principal planes in the immediate neighbourhood of the diffracting structures, and axial distributions for the corresponding components. The results extend the range of the data available previously. The predicted uniformity of the tangential magnetic field in the aperture plane, for the case of a wave incident normally, is verified. An experimental test was made also of the electromagnetic Babinet principle. A.

538.566 : 621.372.8

5529. On the proper frequencies of terminated corrugated waveguides. V. J. VANHUYSE. *Physica*, **21**, *No.* 4, 269–80 (*April*, 1955).

I. Identical cavities (269–74). The properties of circularly symmetric TM-waves in a corrugated waveguide, terminated on both sides in the middle of a corrugation, are deduced from the Maxwell equations. It is assumed that the longitudinal electric field component at each corrugation mouth is an even function. These properties are known and may be proved fairly simply. The interest of the method consists in its usefulness at calculating the natural frequencies of closed systems of cavities with slightly different diameters.

II. Cavities with slightly different diameters (275–80). Following the method worked out in Pt I, approximate frequency equations are obtained for the different resonance modes of circularly symmetric TM-waves in terminated corrugated waveguides, in which the diameters of the cavities may differ slightly. The influence of a definite cavity-diameter on the frequency depends on the considered mode and on the place of the cavity in the system. The results of the theory are tested on systems of 1, 3 and 5 plus 2 half-cavities in which one of them has a radius differing from the others. There is a complete agreement between theory and experiment. A.

538.566 : 621.372.8

5530. An experimental investigation of axial cylindrical surface waves supported by capacitive surfaces. H. E. M. BARLOW AND A. E. KARBOWIAK. *Proc. Instn Elect. Engrs, Paper No.* 1786 R, publ. *May*, 1955 (**102B**, 313–22).

Records experimental work designed to investigate the use of a guide with a capacitive surface impedance for the support of an axial cylindrical surface wave. Previously only inductive surfaces had been employed

for the purpose. A solid dielectric rod, made of Perspex, was used as the guide, and its diameter was carefully adjusted to make the surface impedance come within the particular range of interest. The experiments show that there is no doubt at all about the physical reality of an axial cylindrical surface wave supported by a capacitive surface and having a phase velocity exceeding that of light. Moreover, it has been established that, within the limits of experimental error, such waves vanish completely when the threshold condition necessary for their support in the capacitive region is approached, exactly as predicted by theory. A.

538.566 : 621.372.8

5531. Azimuthal surface waves on circular cylinders. R. S. Elliott. *J. appl. Phys.*, **26**, *No.* 4, 368–76 (*April*, 1955).

Solutions of Maxwell's equations are presented which satisfy the boundary conditions for corrugated and dielectric-clad circular conducting cylinders. These solutions have the physical interpretation of leaky azimuthal surface waves. Values of the complex propagation constant are given as functions of the geometry. For large cylinders the leakage is small and the transmission properties are approximately those of a trapped wave on a flat surface. A coarse experiment gives reasonable agreement with the theory. Some possible applications to transmission lines and aerials are indicated. A.

538.566 : 621.396.67 : 621.3.013

5532. Field produced by an arbitrary slot on an elliptic cylinder. J. R. Wait. *J. appl. Phys.*, **26**, *No.* 4, 458–63 (*April*, 1955).

A derivation is given for the electromagnetic field produced by an arbitrary slot cut in the surface of an elliptic cylinder of perfect conductivity and infinite length. The electric field tangential to the slot is assumed to be a prescribed function. The integrals in the formal solution are evaluated by the saddle point method for the far zone fields which when specialized to thin transverse or axial slots agree with known results. As illustrative examples, patterns of thin axial and transverse slots on a strip are computed. A.

538.566 : 621.396.67

5533. Gap problem in antenna theory. R. King. *J. appl. Phys.*, **26**, *No.* 3, 317–21 (*March*, 1955).

It is shown that whereas there exist problems related to transmission-line end-effect and coupling between aerial and line, there is no gap, and hence no gap problem, when a physically realizable complete transmitting system is considered rather than an aerial with a fictitious mathematically convenient driving mechanism. A.

538.566 : 621.396.677

5534. Radiation characteristics of a conical helix of low pitch angle. J. S. Chatterjee. *J. appl. Phys.*, **26**, *No.* 3, 331–5 (*March*, 1955).

An extension of the author's prior work [*J. appl. Phys.*, **24**, 550 (1953); Abstr. 4346 B (1953)] on the radiation characteristics of and current distribution in a conical helix, the helix used in the present case having a much lower pitch angle. In this case the condition of the phase velocity adjusting itself automatically to maintain maximum directivity condition (which enables the radiation to be confined in the axial mode over a large band of frequencies) does not hold. Nevertheless the major fraction of energy could be radiated in the axial direction when the geometry of the helix and the distance of the apex from the ground were properly chosen, the conical helix together with the ground being regarded as tapered transmission lines (with the ground as one and the helix wire—with the distance of its elements from the ground line increasing continually—as the other line). Measurements of the field intensity and the current distribution were made in the frequency range of 100 Mc/s to 500 Mc/s with a conical helix aerial arrangement as follows. The helix was of six turns, the radius increasing uniformly from 5 cm at the apex to 65 cm at the base within an axial distance of 60 cm. The apex of the helix was placed at a distance of 17·5 cm from the "ground" provided by a 6 ft square copper netting of close mesh. It was found that within the range of frequency measured the major fraction of the energy was radiated in the axial direction. Theoretical expressions for E_ϕ and E_θ were derived by assuming a linear current distribution, and the calculated radiation patterns were found to agree with the experimentally determined ones. A.

538.566.2

5535. Simultaneous partial absorption, reflection and transmission of a uniform plane wave by a thin metallic sheet. M. Gourceaux. *C.R. Acad. Sci. [Paris]* **240**, *No.* 9, 952–3 (*Feb.* 28, 1955) In French.

Absorption, reflection and transmission coefficients are given for a screen, thin compared with the skin depth. It is shown that there is a critical thickness at which the power absorbed is a maximum. At this point half the incident power is absorbed—more than could possibly be absorbed by a thick sheet of the same conductivity. G. D. Sims

538.566.2

5536. Theory of electromagnetic surface waves over geological conductors. J. R. Wait. *Geofis. pura appl.*, **28**, 47–56 (1954).

The radiation fields of a vertical aerial situated on a horizontally stratified ground are discussed. The attenuation and "wave-tilt" of the surface wave and the "height-gain" factor are shown to be a function of the horizontal stratification in the ground. It is possible that the results have application to an airborne geophysical exploration scheme. A.

538.566.2 : 523.5

Forward-scattering of radio waves by meteor trails. *See Abstr.* 5180

538.566.2 : 621.396.11

5537. On the influence on the propagation of very long electric waves of the magnetic field of the earth. W. O. Schumann. Note in *Naturwissenschaften*, **42**, *No.* 4, 91–2 (1955) In German.

A brief note indicating the modifications necessary to previous work [Abstr. 754 B (1954); *Naturwissenschaften*, **40**, *No.* 19, 504–5 (1953)] if a radial magnetic field is assumed to exist in the ionosphere. J. M. Hough

538.566.3

5538. The numerical solution of the differential equations governing the reflexion of long radio waves from the ionosphere. II. K. G. BUDDEN. *Phil. Trans A*, **248**, *No.* 939, 45–72 (1955).

Presents a series of curves which are the results of some calculations of the reflecting properties of various models of the ionosphere for radiowaves of frequency 16 kc/s. The method of calculation was described in a previous paper [Abstr. 2908 (1955)]. No attempt is made to deduce a model of the ionosphere capable of explaining all the observations, but the aim has been rather to establish some general principles which may indicate how future theoretical and experimental work should be planned. In most of the calculations it was assumed that the earth's magnetic field is vertical and that the electron collision frequency in the ionosphere is constant. The limitations imposed by these restrictions are discussed. The first half of the paper describes some calculations for a model of the ionosphere in which the electron density increases exponentially with height and the second half deals with a model having both *D*- and *E*-layers. The results in both cases are compared with observations. A.

538.566.3

5539. The non-existence of a "Fourth reflection condition" for radio waves in the ionosphere. K. G. BUDDEN. *Physics of the ionosphere* [*Cambridge*] 320–31. See Abstr. 5763 (1955).

The refractive index of a magneto-ionic medium, as given by the Appleton–Hartree formula, is infinite for a certain value of the electron density. It has often been stated or implied that when a vertically incident radiowave reaches a level in the ionosphere where this infinity occurs, it is reflected, and the expression for the electron density at this level is called the "fourth reflection condition." Examples are given, which show that in general there is no reflection at a level where the refractive index is infinite, but that the energy in the radiowave is absorbed. This applies even when the electrons make no collisions, so that there is no physical mechanism for the absorption of energy. An explanation for this paradox is suggested. In those cases where reflection has been thought to occur at the level of the "fourth reflection condition," it is shown that the reflection may in fact result from some other cause, such as a zero or a sharp gradient of the refractive index. It is therefore suggested that the term "fourth reflection condition" is misleading, and its use should be discontinued. A.

538.566.3

5540. The mathematics of wave propagation through the ionosphere. K. G. BUDDEN. *Physics of the ionosphere* [*Cambridge*] 276–87. See Abstr. 5763 (1955).

Introduction to Pt IV of this conference.

538.566.3

5541. Electron density and ray tracing in the ionosphere layers. P. A. BRICOUT. *Physics of the ionosphere* [*Cambridge*] 299–307. See Abstr. 5763 (1955).

A good representation of the electron density N in the ionosphere layers as a function of its maximum N_m and of the altitude is given by a function $N = N_m(\frac{1}{2} - a\cos\phi + b\cos^3\phi)$ where $a - b = \frac{1}{2}$ and $\phi = z\pi/e$, z being the height above the base of the layer whose thickness is $2e$. For $a = 9/16$, $b = 1/16$, the formula is a close approximation to the Chapman distribution. The same function gives a good representation of the square of the product nr of the refractive index by the distance to the earth's centre and makes ray tracing in a given ionosphere easier. A nomogram gives the maximum height of the ray. The earth-centre angles for each part of the ray are obtained by numerical integrations, the results of which have been tabulated and represented by curves. The presence of infinite terms in the sums is avoided by replacing the top of the ray by its osculating circle. A radio ray of given frequency and initial incidence may be followed from ground to ground through any ionospheric distribution, this resulting in a relatively easy and exemplified calculation of its range. A.

538.566.3

5542. The dependence of the refractive index in magneto-ionic theory on the direction of the wave normal. P. C. CLEMMOW AND R. F. MULLALY. *Physics of the ionosphere* [*Cambridge*] 340–50. See Abstr. 5763 (1955).

The dependence, in the absence of collisions, of the Appleton–Hartree refractive index μ on the angle θ which the direction of phase propagation makes with that of the (earth's) magnetic field is investigated for all values of the electron density and the strength of the magnetic field. It is shown how the introduction of a suitable parameter enables the (μ, θ) curves [cross-sections of the (μ, θ) surfaces in any plane through their axis of revolution] to be plotted easily in cartesian form. The curves are classified by certain features of their shape into eight distinct types, and the regions in the (X, Y) plane to which these types correspond are specified analytically, X and Y being the familiar dimensionless parameters of magneto-ionic theory. A series of (μ, θ) curves for numerical values of X and Y is drawn, illustrating, in particular, the way in which the changes from one type to another take place via certain limiting shapes. A method of locating points of inflection is suggested. A.

538.566.3

5543. Methods of solving the coupled equations of plane wave propagation in the ionosphere. J. J. GIBBONS. *Physics of the ionosphere* [*Cambridge*] 351–4. See Abstr. 5763 (1955).

A résumé is given of methods used to obtain solutions of the coupled differential equations of plane-wave propagation in the ionosphere. The complex coefficients, functions of height, are understood to be given as tables computed from some electron density–collision frequency model. The methods are for the most part designed for use with a desk computing machine and planimeter. The coupling terms are omitted in the first step, giving two equations of the form $u'' + k^2(x)u = 0$. Three of the methods discussed for handling such equations are: (i) Let $u = p^{-1/2}\exp[\pm\int p]$. Then $\frac{3}{4}(p'/p)^2 - \frac{1}{2}(p''/p) - p^2 = -k^2$, and one solution p gives two independent solutions for u. (ii) The differential equation for the pure travelling wave $\alpha = u/2 - u'/2jk$ is first obtained, and approximate solutions to α rather than u are found. (iii) A second-order convergence iteration

method for the Riccati equation is used [Abstr. 1070 (1955)]. The coupling problem is treated by the method of variation of parameters when coupling is not too large. But as the levels of critical collision frequency and critical electron density approach each other, the coefficients in the coupled equations become infinite. This case has been solved by selecting new modes which avoid this difficulty. A.

538.566.3

5544. Ray theory and a new method for ray tracing. J. HASELGROVE. *Physics of the ionosphere* [*Cambridge*] 355–64. See Abstr. 5763 (1955).

The method of Hamilton gives the differential equations governing ray paths in an anisotropic medium in a form which is suitable for integration by standard numerical methods using an electronic computer. This gives a new way of calculating ionospheric ray paths and associated quantities such as the absorption. The method has been shown to give considerable speed and accuracy. A.

538.566.3

5545. Studies of the refractive index in the ionosphere: the effect of the collision frequency and of ions. W. PFISTER. *Physics of the ionosphere* [*Cambridge*] 394–401. See Abstr. 5763 (1955).

With the increased emphasis on low frequency ionospheric work and with an improved knowledge of upper atmospheric data it becomes important to reconsider the accuracy of the familiar refractive index formula. The Appleton–Hartree formula incorporates the collisions of electrons with neutral molecules in a simplified manner. It disregards the thermal velocity distribution of the electrons. A more complicated and physically more satisfactory formula has been given by Huxley. A comparison between the two formulae reveals that the Appleton–Hartree formula can be used in the case of sufficiently small collision frequencies provided they are replaced by 4/3 of their mean value. For higher collision frequencies corrections have to be applied. They depend on the assumed model of collisional cross-section, and can be as high as 50% for the conductivity. Two cases of cross-section models have been considered, the case of constant collision frequency and the case of constant freepath length. An example of the refractive index at the gyrofrequency has been computed. The effect of ions has been studied by assuming four kinds of particles: electrons, neutral particles, positive ions and negative ions. The four equations of motion are connected with terms containing collisions between all kinds of particles. With the assumption of an electron drift velocity large compared with that of the heavy particles, a modified Appleton–Hartree formula can be derived. If second-order correction terms are neglected, this is identical with a modification developed by Goubau, provided the total number of electron collisions is used instead of the collisions with neutral particles only. A.

538.566.3

5546. Tables of group refractive index for the ordinary ray in the ionosphere. D. H. SHINN. *Physics of the ionosphere* [*Cambridge*] 402–6. See Abstr. 5763 (1955).

For various theoretical calculations connected with $h'(f)$ observations it is necessary to know μ', the "group refractive index" of the ionosphere. This is defined as the free space velocity of light divided by the vertical component of the group velocity of the wave. This definition is valid for both vertical and oblique incidence. The tables represented here refer only to vertical incidence. In this case μ' is a function of X, Y and ϕ, where X is proportional to (electron density)/f^2, Y is equal to (gyromagnetic frequency)/f, and ϕ is the angle of dip of the earth's magnetic field. It is convenient to define $t = (1-X)^{1/2}$, and to tabulate $\mu' t$ against t. Tables are presented covering values of t from 0 to 1, of Y from $\frac{1}{3}$ to 1, and of ϕ from 0° to nearly 80°. Methods of using the tables are discussed. Absorption due to electronic collisions is neglected throughout. A.

538.566.3 : 551.510.535

5547. Comment on the theory of radio-wave interaction. L. G. H. HUXLEY. *Proc. Roy. Soc. A*, **229**, 405–7 (*May* 10, 1955).

Certain difficulties associated with the current interpretation of ionospheric cross-modulation effects are pointed out and discussed. These arise essentially from the recent measurements which show how the mean energy lost by an electron in a collision with a gas molecule depends upon the excess of the mean energy of the electron above that of a gas molecule. When applied to ionospheric conditions these data do not give results consistent with the observations of cross-modulation. A.

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11 : 539.152.1 : 530.145

Topics from the conference of physicists at Spała [Poland]. *See Abstr.* 5213

539.11 : 539.32 : 536.71

5548. Equation of state and the thermal dependence of the elastic coefficients of crystalline argon. J. H. HENKEL. *J. chem. Phys.*, **23**, *No.* 4, 681–7 (*April*, 1955).

An interaction potential of the form $A/R^{10} - B/R^6$ for two argon atoms is assumed. The values of A and B are evaluated using the heat of sublimation and the lattice constant at temperature $T = 0°K$ and pressure $p = 0$. By assuming that each atom moves in a potential field due to all the other atoms at rest in their mean positions, a theory is developed for anharmonic vibrations using the perturbation theory for a harmonic oscillator. The partition function for each argon atom is obtained and the equation of state is calculated. The specific-heat equation obtained represents a correction of the Einstein form. The specific heats at constant pressure are calculated as a function of temperature and deviate from the experimental ones by only 3% at low temperatures (15°K–30°K) and only 1% at higher temperatures. The isothermal elastic coefficients C_{11}, C_{12} and C_{44} are calculated by Born's method without neglecting the part played by the thermal energy. The Cauchy relation is found to be invalid, C_{44} being about twice C_{12} at the higher temperatures. A.

MOLECULES 539.13

539.13

5549. Derivation of an internuclear potential function from a quantum mechanical model. E. R. LIPPINCOTT. Letter in *J. chem. Phys.*, **23**, *No.* 3, 603 (*March*, 1955).

The molecular potential function proposed previously [Abstr. 2661 (1954)], and a relation determining one of the parameters, are deduced from a quantum mechanical picture of molecules in which the potential is represented by a sum of delta functions. This is illustrated by calculations on the H_2^+ and H_2 molecules. A factor introduced to allow for interelectronic repulsion is found to vary little between molecules. A. J. TAYLOR

539.13

5550. Effect of a repulsive force on the scattering of ions by molecules. V. W. MYERS. Letter in *J. chem. Phys.*, **23**, *No.* 4, 755 (*April*, 1955).

A potential $(-kr^{-n} + Lr^{-2n})$ is used in the interpretation of the experiments on scattering of ions by molecules, particularly H_2^+ by He, done by Simons *et al.* [*J. chem. Phys.*, **11**, 307, 322 (*July*, 1943)] and previously interpreted in terms of a simple attractive potential. Agreement with experiment is reasonable. J. HAWGOOD

539.13 : 539.156

5551. A suggested method for studying the mechanism of energy transfer in collisions. T.-Y. WU. *Canad. J. Phys.*, **33**, *No.* 5, 151–5 (*May*, 1955).

It is shown that information can be obtained concerning the nature of the energy-transfer process in collisions in which an excited atom (or molecule) A′ transfers its energy of excitation to another atom (or molecule) B, $A' + B \rightarrow A + B'$, cross-section σ_q, by comparing the experimental value of the ratio of the cross-section σ_q and the σ_{ex} of the inverse process with the theoretical values of this ratio for various modes of excitation of B, which values can be readily obtained from statistical mechanical considerations alone. For example, for the study of the nature of the "quenching" collisions, the ratio σ_q/σ_{ex} can be determined from a measurement of the intensity of the radiation emitted by A′ as a function of time. Such measurements are possible with the photomultiplier and electronic timing circuit techniques now available. A.

539.132 : 535.343 : 537.226 : 541.1

An advanced treatise on physical chemistry. Molecular spectra and structure, dielectrics and dipole moments. *See Abstr.* 5682

539.132

5552. The electrostatic method and the combined approximation approach. H. PREUSZ. Note in *Z. Naturforsch.*, **10a**, *No.* 2, 165–6 (1955) In German.

It is remarked that the electrostatic method for the calculation of chemical bond energies and bond lengths developed by Hurley [Abstr. 1089–91 (1955)] can be extended to four-electron systems with the use of the combined approximation method of Hellmann [*J. chem. Phys.*, **3**, 61 (1935)]. By this method the necessary orthogonality of the eigenfunctions of the valence electrons is replaced by a parameter which can be taken into account in the total force between electron and nucleus. A. J. TAYLOR

539.132

5553. Asymmetric rotor. XII. The infrared spectrum of hydrogen sulfide from 7480 to 7880 cm^{-1}. G. L. ORDWAY, P. C. CROSS AND E. J. BAIR. *J. chem. Phys.*, **23**, *No.* 3, 541–3 (*March*, 1955).

For Pt XI, see Abstr. 3496 (1953). About two hundred lines have been observed in the spectrum. The absorption has been analysed as due to three levels of the interacting Darling–Dennison pairs $(v_1v_2v_3) =$ (201) (003) and (102) (300). The constants obtained were for (201) $\nu_0 = 7576{\cdot}3$, $A' = 9{\cdot}97$, $B' = 8{\cdot}54$, $C' = 4{\cdot}55\,\text{cm}^{-1}$; for (300) $\nu_0 = 7751{\cdot}9$, $A' = 10{\cdot}08$, $B' = 8{\cdot}52$, $C' = 4{\cdot}54\,\text{cm}^{-1}$; and for (003), $\nu = 7779{\cdot}2$, $A' = 9{\cdot}80$, $B' = 8{\cdot}68$, $C' = 4{\cdot}57\,\text{cm}^{-1}$. The (102) band, expected to be very weak, may be coincident with the (201) band and have approximately the same constants. A.

539.132

5554. Transformation useful in computing vibrational overlap integrals. M. L. COFFMAN. Letter in *J. chem. Phys.*, **23**, *No.* 3, 585–6 (*March*, 1955).

Such integrals between different vibrational wavefunctions for non-linear symmetrical XY_2 molecules, can be simplified by expressing the symmetrical normal co-ordinates of one state as a linear combination of those for the other, and the asymmetrical normal co-ordinate of one as a multiple of that for the other. J. HAWGOOD

539.132

5555. Substituted methanes. XXI. Calculated and observed wave numbers, and calculated thermodynamic properties, for bromodeuteromethane and bromodideuteromethane. J. M. DOWLING. *J. chem. Phys.*, **23**, *No.* 4, 700–1 (*April*, 1955).

For Pt XX, see Abstr. 8483 (1954). Using potential energy constants obtained from CH_3Br and CD_3Br, wave numbers (fundamentals) for CH_2DBr and CHD_2Br were calculated by means of the Wilson FG matrix method with a potential energy function containing all possible second degree terms. The calculated values of the wave numbers were then used to assign existing infrared and Raman spectral data for these molecules. Then the heat content, free energy, entropy and heat capacity for the ideal gaseous state at 1 atm pressure were calculated for 12 temperatures from 100 to 1000°K with a rigid rotator, harmonic oscillator approximation. A.

539.132

5556. Substituted methanes. XXII. Infrared spectra of $CHBrF_2$, and potential constants and calculated thermodynamic properties of $CHBrF_2$ and $CDBrF_2$. A. PALM, F. L. VOELZ AND A. G. MEISTER. *J. chem. Phys.*, **23**, *No.* 4, 726–8 (*April*, 1955).

The near infrared spectrum of gaseous bromodifluoromethane was obtained using a Perkin–Elmer Model 21 Spectrometer equipped with a NaCl prism. A set of potential constants was determined for $CHBrF_2$ by means of the Wilson FG matrix method, using a potential energy function with all possible second-degree terms. The same potential constants were used to calculate the fundamentals of $CDBrF_2$. Finally the heat content, free energy, entropy and heat capacity were calculated for 12 temperatures from

100 to 1000°K, for the ideal gaseous state at 1 atm pressure, using the observed fundamentals for $CHBrF_2$ and the calculated ones for $CDBrF_2$. A.

539.132

5557. Substituted methanes. XXIII. Infrared spectral data, rotational constants, normal coordinate treatments, and thermodynamic properties for CD_3Br and CH_3Br. H. B. Weissman, R. B. Bernstein, S. E. Rosser, A. G. Meister and F. F. Cleveland. *J. chem. Phys.*, **23**, *No.* 3, 544–51 (*March*, 1955).

Infrared spectra were obtained between 400 and 4000 K with NaCl and KBr prisms. The a_1 fundamentals for CD_3Br are 2157, 993 and 578 K; for CH_3Br they are 2972, 1305 and 611 K. For CD_3Br, a least squares analysis of the observed wave numbers of the subbands of $\sigma_6(e)$ gave for B_1, A_1, ζ and σ_0 the values 0·255 K, 2·529 K, 0·150 and 712·3 K; for $\sigma_5(e)$ the values were 0·257 K, 2·530 K, −0·339 and 1056·2 K. For $\sigma_4(e) = 2293$ K, the subbands were not resolved, but the sum rule gave $\zeta_4 = 0{\cdot}240$. The microwave value of B_0 was used. The signs of $B_1 - B_0$ for σ_6 and σ_5 are the same as those previously obtained for CH_3I by use of the high-dispersion records of Lagemann and Nielsen. For CH_3Br, a least squares analysis of the grating data of Bennett and Meyer gave for $\sigma_6(e)$: 0·315 K, 5·144 K, 0·217 and 955·4 K; for $\sigma_5(e)$: 0·304 K, 5·062 K, −0·242 and 1448·2 K; and for $\sigma_4(e)$: 0·321 K, 5·153 K, 0·064 and 3055·6 K. The sign of $B_1 - B_0$ for σ_6 is the same as for CH_3I, but the signs for σ_5 and σ_4 are reversed. This inconsistency is presumably due to the limited accuracy with which the two small constants $B_1 - B_0$ and $(A_1 - B_1) - (A_0 - B_0)$ can be determined by the least squares method. The most probable values of the band origins are believed to be 954·5, 1443·8 and 3056·7 for CH_3Br and 711·6 and 1056·4 K for CD_3Br (σ_4 was not resolved, so no band origin could be obtained). Values of the principal potential constants are: $f_b = 2{\cdot}8631$ md/A, $f_h = 5{\cdot}1199$ md/A, $f_{hh} = 0{\cdot}53535$ md A/rad^2 and $f_{bh} = 0{\cdot}62871$ md A/rad^2. Values are given for 13 interaction constants. For CD_3Br, the values of $(H^0 - E_0^0)/T$, $-(F^0 - E_0^0)/T$, S^0 and C_p^0 at 100, 273·16, 298·16, 900 and 1550°K are respectively: 7·95, 42·66, 50·61, 8·00; 8·75, 50·86, 59·61, 11·07; 8·98, 51·63, 60·61, 11·68; 14·23, 64·09, 78·32, 20·38; and 17·57, 72·74, 90·31, 23·44 cal deg^{-1} mole^{-1}. For CH_3Br, the corresponding values are: 7·95, 41·41, 49·36, 7·97, 8·37, 49·51, 57·88, 9·72; 8·50, 50·25, 58·75, 10·14; 12·63, 61·51, 74·14, 18·19; and 15·87, 69·25, 85·12 and 22·00. Values for 27 other temperatures in this range are given. A.

539.132

5558. Substituted methanes. XXV. Potential constants and calculated thermodynamic properties of dibromofluoromethane. H. Murata, A. Palm and A. G. Meister. *J. chem. Phys.*, **23**, *No.* 4, 702–3 (*April*, 1955).

For Pt XXIV, see Abstr. 419 (1955). On the basis of previous Raman data, a reasonable set of potential constants was calculated for $CHFBr_2$ by the Wilson method, assuming a most general quadratic potential energy function. The thermodynamic properties—heat content, free energy, entropy and heat capacity—for the ideal gaseous state at 1 atm pressure were computed for 12 temperatures from 100 to 1000°K. A.

539.132

5559. Measurement of bond moments in C_2H_2 and C_2D_2 from infrared intensities. E. C. Wingfield and J. W. Straley. *J. chem. Phys.*, **23**, *No.* 4, 731–3 (*April*, 1955).

The absolute infrared absorption intensities in the active bending vibration ν_5 in C_2H_2 and C_2D_2 have been measured using the extrapolation method of Wilson and Wells. The intensities observed are $A_5(C_2H_2) = 2170 \times 10^{10}$ c/s. cm at N.T.P. and $A_5(C_2D_2) = 1040 \times 10^{10}$ c/s. cm at N.T.P. These values indicate the bond moment associated with the CH and the CD bonds are $\mu_{CH} = 0{\cdot}999 \pm 0{\cdot}035$ debye and $\mu_{CD} = 0{\cdot}941 \pm 0{\cdot}033$ debye, respectively. A.

539.132

5560. Mean amplitudes of thermal vibrations in polyatomic molecules. III. The generalized mean amplitudes. Y. Morino and E. Hirota. *J. chem. Phys.*, **23**, *No.* 4, 737–47 (*April*, 1955).

For Pt II, see Abstr. 1524 (1954). James's theory of the effect of molecular vibrations upon the diffraction pattern is revised and extended, including the parallel as well as perpendicular vibrations of atom pairs. Corresponding to these vibrations the mean square amplitudes, parallel and perpendicular, and the mean cross products are defined, and a method of calculating them by means of normal modes of vibration is derived. At the same time the effect of molecular symmetry upon mean amplitudes is discussed with the result that some of them are essentially reduced to zero because of the symmetry. A.

539.132

5561. On the $^4\Pi$ state of the O_2^+ molecule. A. Budó and I. Kovács. Letter in *J. chem. Phys.*, **23**, *No.* 4, 751–2 (*April*, 1955).

Inclusion of spin-orbit coupling terms as well as rotation-vibration terms in the electronic Hamiltonian allows the $^4\Pi$ state of O_2^+ to interact with two nearby $^2\Pi$ states, and brings the splitting of the multiplet calculated by second order perturbation into good agreement with experiment. J. HAWGOOD

539.132 : 535.343

The influence of vibration-rotation interaction on line intensities. *See Abstr.* 5317

539.132

5562. Lowest triplet levels of the polyacenes. S. P. McGlynn, M. R. Padhye and M. Kasha. Letter in *J. chem. Phys.*, **23**, *No.* 3, 593–4 (*March*, 1955).

A weak absorption found in anthracene at 14858 cm^{-1} has been proved intercombinational ($T \leftarrow S$), and the converse phosphorescent emission has been photographed. It is orbitally allowed, $u \rightarrow g$. Extrapolation of the lowest triplets of the polyacene series indicates one for naphthacene which has been found using solvent-perturbation techniques at about 10250 cm^{-1} as expected, and as other calculations predict. Further extrapolation leads to the conclusion that the higher polyacenes have very low-lying triplet levels. A. J. TAYLOR

539.132

5563. Lowest singlet excited levels of naphthalene. C. M. MOSER AND R. LEFEBVRE. Letter in *J. chem. Phys.*, **23**, *No.* 3, 598 (*March*, 1955).

Describes a limited configuration interaction treatment for these levels, using semi-empirical methods to evaluate the integrals, and comparing the results of starting with different MO's. The first transition is polarized along the long axis ($^1B_{1u}$) and the second along the short axis ($^1B_{2u}$), and the first intensity is diminished by the configuration interaction. Configurations made to resemble benzene [see Moffitt, Abstr. 4352 (1954)] are better than those using Hückel-like orbitals. J. HAWGOOD

539.132

5564. On the electronic structure and electronic spectra of ethylene-like molecules. R. G. PARR AND R. PARISER. *J. chem. Phys.*, **23**, *No.* 4, 711–25 (*April*, 1955).

A previously given theory of the electronic spectra and electronic structure of complex unsaturated molecules is applied to ethylene-like molecules, molecules such as ethylene itself, propylene or formaldehyde, which have two π-electrons and two atomic π-orbitals available for π-bond formation. Relations are derived among electronic excitation energies, intensities of electronic transitions, extra-ionic resonance energies and dipole moments of such molecules. Relative electronegativities are shown to play an important rôle in these relations, where the effective electro-negativity of an atom is Mulliken's electronegativity (the mean of the appropriate atomic valence-state ionization potential and electron affinity) plus the total attraction of the valence electron of the atom for all other atoms in the molecule. The analysis yields the result that the dipole moment due to a slight bond heteropolarity is proportional to the electronegativity difference of the bonded atoms, the extra-ionic resonance energy to its square. Proportionality factors are given absolutely by the theory. It is pointed out that the theory of a two-electron σ-bond is formally the same, moreover, so that a derivation is provided for the familiar electronegativity relations of Pauling. Theoretical and empirical values for the proportionality factors are found to agree reasonably well for both π-bonds and σ-bonds. The formulae given cover multiple perturbations of any type which may be considered not to add (or subtract) π-electrons or π-orbitals. They thus provide a scheme for quantitative evaluation of inductive effects in ethylene-like molecules. Systematic consideration of mesomeric effects is deferred, but an outline of the procedure which may be used for their study is given, using mono-substituted ethylene as an example. To illustrate the use of the formulae, to bring out the relationships between the method and the work of other authors, and to see whether the method has promise for σ-electron systems, calculations are made of the electronic spectrum of ethylene, the twisting force constant of ethylene, the ionization potential and electron affinity of ethylene, the electronic spectrum and dipole moment of formaldehyde, and the electronic spectrum, ionization potential, and binding energy of the hydrogen molecule. A.

539.132

5565. Cl^{35} pure quadrupole resonances in acid chlorides and chlorates. P. J. BRAY. *J. chem. Phys.*, **23**, *No.* 4, 703–6 (*April*, 1955).

The pure quadrupole resonances of Cl^{35} in acid chlorides of some aliphatic dicarboxylic acids have been observed. No resonances have been found in acid chlorides of aliphatic monocarboxylic acids which retain the unsubstituted CH_3 configuration at the chain end not occupied by the COCl group. This absence of resonances is attributed to possible randomness in the crystal structure or thermally activated low-frequency reorientations of groups within the molecule. Resonances have also been measured in several chlorates, sulphuryl chloride, iodine monochloride, iodine trichloride and selenium tetrachloride. Structural and bonding discussions are given for the latter two compounds. A.

539.132

5566. Molecular orbital approximation to electron-spin coupled nuclear spin-spin interactions in molecules. H. MCCONNELL. Letter in *J. chem. Phys.*, **23**, *No.* 4, 760 (*April*, 1955).

Fine-structure multiplets in some nuclear magnetic resonance spectra have been ascribed to indirect interaction between nuclear spins *via* electronic spins [Abstr. 2884 (1952), 7006 (1953)]. A single-determinant LCAO MO electronic wave-function is used to obtain an expression for the nuclear spin-spin coupling constant. The higher MO's are mainly responsible for the coupling. Bond orders and bond angles are important in determining the coupling, which may be positive or negative. J. HAWGOOD

539.132 : 535.343

5567. New radioelectric method for the study of the structure of matter in the solid phase. J. DUCHESNE AND A. MONFILS. *Bull. Acad. Roy. Belgique Cl. Sci.*, **41**, *No.* 2, 165–87 (1955) In French.

A new effect of resonance absorption corresponding to high quantum numbers of vibration was discovered, in the solid state, in the radiofrequency region. The substances investigated were the antibiotics chloramphenicol (levo- and racemic forms) and oxytetracyclin. The spectra are constituted of a great number of very narrow lines. A saturation effect of these lines has been observed from which a relaxation time has been deduced and studied as regards its dependence upon temperature. Among other characteristics, a very definite and reversible shift of the lines with temperature has been proved and the law concerning this has been given. A new displacement constant $\Delta(T)$ emerges and this has been correlated with Grüneisen's thermodynamic constant γ. The latter has been analysed. The method appears to be of wide application and may be invaluable in the study of the most elaborate compounds and in the distinguishing of substances of almost identical structures. A.

539.132

5568. Electronic structure of water molecule. Y. AMAKO. *Sci. Rep. Tôhoku Univ. First Ser.*, **38**, *No.* 1, 77–84 (*June*, 1954).

Assuming the bond distance 0·955 Å and bond angle 104° 40′, the ground state of the H_2O molecule was

treated by Roothaan's self-consistent field method. The interactions of all electrons except those in the *K*-shell of the oxygen atom were considered. Recently Ellison and Shull reported the same attempt as the present work, but with different parameters, which was in an excellent agreement with experimental data, especially in the ionization potential. The present work is in poorer agreement in the ionization potential; calculated potentials are 8·08 eV for a b_1 electron and 15·75 eV for a $2a_1$ electron, compared with the experimental values 12·6 eV and 14·5 eV, respectively. But in dipole moment the calculated value 1·75*D* agrees fairly well with the experimental 1·84*D*. Three-centre and some other small integrals were calculated under the approximation taken by R. S. Mulliken. A.

539.132

5569. Molecular orbital calculation on phthalocyanine. S. Basu. *Indian J. Phys.*, **28**, *No.* 11, 511–21 (*Nov.*, 1954).

MO calculations have been made on phthalocyanine and the permanent charge distribution has been correlated with the chemical reactivity of the different positions of the molecule. A prediction of the allowed spectral transition has also been made from the calculated energy levels of the π-electrons. A.

539.132

5570. On the LCAO coefficients of naphthalene obtained by a semi-empirical approximation of the self-consistent-field method. C. M. Moser. *J. Chim. phys.*, **52**, *No.* 1, 24–33 (*Jan.*, 1955) In French.

The calculated values of the coefficients of molecular orbitals, linear combinations of atomic orbitals (MO LCAO), are used to discuss some of the molecular properties of naphthalene, e.g. ionization potential, interatomic distances and chemical reactivity.

G. I. W. Llewelyn

539.132

5571. Electronic structure of heptafulvene. Study by the self-consistent molecular field method. A. Julg. *J. Chim. phys.*, **52**, *No.* 1, 50–2 (*Jan.*, 1955) In French.

The calculated values of the dipole moment (0·14 Debye) and the energy of transition $N \rightarrow V_1$ (5·11 eV) are considerably different from those deduced using the theory of linear combination of atomic orbitals. The results support the hypothesis that the heptagonal cycle is planar.

G. I. W. Llewelyn

539.132

5572. Atom-stabilization energies in conjugated systems. T. Nakajima. Letter in *J. chem. Phys.*, **23**, *No.* 3, 587 (*March*, 1955).

The total binding energy of the π-electrons in the LCAO MO treatment of conjugated systems may be written as the sum of "stabilization" energies for each atom. These quantities form a reliable measure of the reactivities of the corresponding positions for alternant hydrocarbons, the smallest stabilization energy indicating the greatest reactivity. Corresponding quantities may be defined for ionized molecules, determining the reactivity for electrophilic substitution. J. Hawgood

539.132

5573. An approximate method for the determination of orbitals. R. Lefebvre. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1094–5 (*March* 7, 1955) In French.

It is shown how configuration interaction may be used to obtain approximately orbitals which will minimize the energy of a given combination of Slater determinants. These orbitals are obtained in terms of a set of supposed known orbitals. The MO's of trans-butadiene are worked out as an example; it is found that the lowest B_u state can be represented satisfactorily by a single configuration. A. J. Taylor

539.132

5574. The inclusion of overlap in molecular orbital calculations on heterocyclic molecules. D. W. Davies. *Trans Faraday Soc.*, **51**, *Pt* 4, 449–57 (*April*, 1955).

The effect of including overlap in LCAO MO calculations is discussed. It is shown that the Wheland relationship between the orbital energies with and without overlap holds for heterocyclic molecules only if a certain condition is satisfied. A perturbation method is given for deriving the orbital energies with overlap from those without. The results of calculations of energies of the *N-V* transition, resonance energies, charge densities, dipole moments, bond orders, free valencies and frontier electron densities both with and without overlap for pyridine, pyridazine, pyrimidine, pyrazine and *s*-triazine are given. The results of the two sets of calculations are very similar and are found to be in good agreement with experiment. The frontier electron densities are, however, found to be in poor agreement with the chemical evidence, and the reason for this is discussed. A.

539.132

5575. An LCAO MO study of the structure of chlorophyll prototypes. S. L. Matlow. *J. chem. Phys.*, **23**, *No.* 4, 673–80 (*April*, 1955).

By means of Wheland's method of treating systems with hetero-atoms three possible isomers of porphyrin and five of dihydroporphyrin are studied from the viewpoint of the energies of the ground states and the transition energies of the lowest lying excited states. In the case of porphyrin it is found that, within the limits of accuracy of the method used, two of the structures, PA (porphyrin-adjacently bonded hydrogens) and PO (porphyrin-oppositely bonded hydrogens), have identical ground state energies. In the case of dihydroporphyrin the DHP-AI (DHP-A—dihydroporphyrin-adjacently bonded hydrogens) isomer is most stable and the DHP-AII and DHP-OII (DHP-O—dihydroporphyrin-oppositely bonded hydrogens) isomers are more energetic by 1·06 and 1·20 kcal/mole, respectively. With respect to the transition energies and the resulting spectra it is possible that the peaks in the spectrum of porphyrin are not due mainly to vibrational fine structure of a single electronic transition, as is proposed by Rabinowitch, but rather are the combination of the electronic spectra of the PA and PO isomers. The dihydroporphyrin spectral analysis, however, indicates that several of the peaks are probably vibrational fine structure of a single electronic transition. The calculated bond orders are given for the various structures discussed. A.

539.132 : 539.133

5576. The calculation of bond lengths in naphthalene and anthracene. H. O. PRITCHARD AND F. H. SUMNER. *Trans Faraday Soc.*, **51**, *Pt* 4, 457–62 (*April*, 1955).

The bond orders in naphthalene and anthracene are calculated by six different molecular orbital approximations: the corresponding bond lengths are compared with experimental values, but no approximation gives satisfactory agreement for both molecules; the major source of discrepancy does not appear to lie in the inadequacies of the bond order against bond length relationship used. A.

539.133

5577. Nuclear resonance spectra of rubidium and ammonium fluoroborates. D. PENDRED AND R. E. RICHARDS. *Trans Faraday Soc.*, **51**, *Pt* 4, 468–75 (*April*, 1955).

Proton and fluorine magnetic resonance spectra are given for crystalline rubidium and ammonium fluoroborates at 20°K and at 90°K. The measurements on the rubidium salt lead to a B–F distance in the BF_4^- ion of $1{\cdot}43 \pm 0{\cdot}03$ Å. In the ammonium salt, the proton resonance line is considerably narrowed by molecular motion even at 20°K, and the results are best interpreted in terms of hindred motion of the ammonium ion about a C_2 axis which is associated with a very low potential barrier. A.

539.133

5578. On the theory of directed valence: polarization of a carbon atom by a proton. M. ROUX AND R. DAUDEL. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1091–3 (*March* 7, 1955) In French.

Calculated contours are drawn of the electron density in a CH group of internuclear distance 1·09 Å. It is found that at this distance from the C nucleus, points of maximum electron density are on a line at about 110° from the CH axis. Another proton would tend to approach this position. A. J. TAYLOR

539.133

5579. On the helical configuration of a polymer chain. T. SHIMANOUCHI AND S. MIZUSHIMA. *J. chem. Phys.*, **23**, *No.* 4, 707–11 (*April*, 1955).

A mathematical expression for the helical configuration of a polymer chain has been derived as a function of the bond lengths, bond angles and internal rotation angles. The result of the calculation has been applied to the determination of stable configurations of several polymer chains. A.

ATOMS . NUCLEUS . ISOTOPES 539.15

539.152.1

5580. The summation rule for B_p, B_n. A. BASU (MITRA). *Indian J. theor. Phys.*, **2**, *No.* 2, 91–3 (*Sept.*, 1954).

A new summation rule for the proton and neutron binding energies is stated. It is shown that with the help of this rule unknown values of B_p, B_n may be determined in many cases. A.

539.152.1

5581. The nuclear potential well for high energy nucleon scattering. G. Z. SHAH AND K. M. GATHA. Letter in *Curr. Sci.*, **23**, *No.* 12, 395 (*Dec.*, 1954).

The nuclear potential employed in the optical model of the nucleus can be obtained from the nucleon-nucleon forward scattering amplitudes. The potential necessary to explain high-energy scattering experiments agrees with that from the amplitudes resulting from the tensor interaction of Christian and Hart [Abstr. 4377 (1950)] and Christian and Noyes [Abstr. 8804 (1950)]. G. E. BROWN

539.152.1

5582. A contribution to the theory of nuclei with a diffuse surface. Z. JANKOVIĆ. *Phil. Mag.*, **46**, 376–80 (*April*, 1955).

The sharp edge of the complex square-well potential of Feshbach, Porter and Weisskopf [Abstr. 524 (1955)] is modified so that the potential varies continuously (and linearly) from its interior value to zero. Values of the total neutron scattering cross-section and of the resonance widths are given as a function of the nuclear radius R. G. E. BROWN

539.152.1

5583. Nuclear surface energy and the diffuseness of the nuclear surface. W. J. SWIATECKI. Letter in *Phys. Rev.*, **98**, *No.* 1, 203–4 (*April* 1, 1955).

An attempt to relate the magnitude of the surface region, illustrated by a calculation on a Fermi gas, suggests a diffuseness of order $\sim 7 \times 10^{-13}$ cm (see abstract following). W. J. SWIATECKI

539.152.1

5584. Average nuclear potentials and densities. W. J. SWIATECKI. Letter in *Phys. Rev.*, **98**, *No.* 1 204–5 (*April* 1, 1955).

The observation that the faster particles in nucleus will explore a relatively greater volume points to a connection between the surface energy, the diffuseness of the surface and the enrichment of the surface in neutrons. This is illustrated for a Fermi gas in wells with linearly sloping sides.

W. J. SWIATECKI

539.152.1

5585. The structure of the nuclei of mass 18 and 19. J. P. ELLIOTT AND B. H. FLOWERS. *Proc. Roy. Soc. A*, **229**, 536–63 (*May* 24, 1955).

An intermediate coupling calculation has been carried out for nuclei of mass 18 and 19, taking full account of the configurational mixing of the 2*s* and 1*d* shells. The spin-orbit splitting of the *d*-level and the relative position of the *s*-level are taken from the observed O^{17} spectrum, while the strength of the two-body central force is treated as a free parameter. No excitation of the O^{16} closed shell core is considered. Excellent agreement is found for the positions of the even-parity energy levels and their properties, including the reaction data. The configurational mixing is very large, the strength of central force is similar to that required for the deuteron and the mode of coupling is similar to that in the lithium nuclei. A.

539.152.1 : 539.11 : 530.145

Topics from the conference of physicists at Spała [Poland]. *See Abstr.* 5213

539.152.2

5586. Magnetic moment of the 247-keV excited state of the Cd^{111} nucleus. R. M. STEFFEN AND W. ZOBEL. Letter in *Phys. Rev.*, **97**, *No.* 4, 1188–9 (*Feb.* 15, 1955).

From the ratio $C_{135°}(+H)/C_{135°}(-H)$ of the coincidences of the two γ-rays in magnetic fields pointing up (+H) and down, the magnetic moment is determined to be $\mu_{s/2} = -(0{\cdot}783 \pm 0{\cdot}028)$ nuclear magnetons. This determination is insensitive to the quadrupole interaction parameter. G. E. BROWN

539.152.2

5587. Nuclear electric quadrupole moment of Na^{23} by the atomic beam resonance method. M. L. PERL, I. I. RABI AND B. SENITZKY. *Phys. Rev.*, **98**, *No.* 3, 611–26 (*May* 1, 1955).

The hyperfine structure of the $n = 3^2P_{\frac{1}{2}}$ and $^2P_{\frac{3}{2}}$ excited atomic states of Na^{23} have been investigated using a modification of the atomic beam resonance method. The *C* region is illuminated with resonance radiation from a sodium discharge lamp which brings some of the atoms into the excited levels where they have lifetimes of the order of 10^{-8} sec. The application of an r.f. field of an appropriate frequency causes transitions among the excited state hyperfine levels and "scrambles" the populations of these levels. Since the atoms are essentially "tagged" by the deflection which they have undergone in the *A* field, this "scrambling" will cause a change in the refocused intensity at the detector. Measurements of the hyperfine structure at weak fields give the values: $a_{\frac{1}{2}} = 94{\cdot}45 \pm 0{\cdot}5$ Mc/s for the $3^2P_{\frac{1}{2}}$ state; $a_{\frac{3}{2}} = 19{\cdot}06 \pm 0{\cdot}36$ Mc/s for the $3^2P_{\frac{3}{2}}$ state; and $b = +2{\cdot}58 \pm 0{\cdot}3$ Mc/s or $b = -21{\cdot}64 \pm 0{\cdot}7$ Mc/s for the $3^2P_{\frac{3}{2}}$ state. The strong-field spectrum of the $3^2P_{\frac{3}{2}}$ state strongly indicates that the correct value of b is $+2{\cdot}58 \pm 0{\cdot}3$ Mc/s. The possible values of Q are $+0{\cdot}100 \pm 0{\cdot}011 \times 10^{-24}$ cm for $b = +2{\cdot}58$ Mc/s, or $-0{\cdot}836 \pm 0{\cdot}028 \times 10^{-24}$ cm for $b = -21{\cdot}64$ Mc/s. A.

539.152.2

5588. Quadrupole resonance in liquids. J. SEIDEN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1419–21 (*March* 28, 1955) In French.

A theoretical discussion shows that if any molecular motion in a liquid is slow compared to the quadrupole transition frequency, resonance may be observed at a frequency intermediate between that for the solid and zero. Liquid crystals, very viscous liquids and partially ordered liquids as *p*-dibrombenzene may show resonance. D. H. WHIFFEN

539.153.4

5589. Note on a search for simple analytic wave functions for configurations $(1s)^2(2s)$ and $(1s)^2(2s)^2$ in atoms and ions from He to C. E. HOLØIEN. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 297–303 (*April*, 1955).

Simple analytical expressions for these wave-functions, made up out of one-electron functions (orbitals), are given. Results for energies are almost as good as those given by the Hartree–Fock functions. G. E. BROWN

539.154.3

5590. The magnetic moments of cobalt–copper alloys. J. CRANGLE. *Phil. Mag.*, **46**, 499–513 (*May*, 1955).

The rate of change of atomic moment with electron concentration for the high-temperature face-centred cubic form of the solid solution of copper in cobalt has been derived from measurements on the variation of spontaneous magnetization of suitable alloys with temperature. It is quite close to the rate previously observed for solutions of copper in nickel, and the moment extrapolates to a value at the electron concentration of pure nickel which is near that previously measured directly. The Law of Corresponding States does not hold for this system, and the fullness of the reduced magnetization temperature curves increases with the copper concentration, in contrast with the decrease in fullness often observed previously in similar measurements on other alloy systems. A.

RADIOACTIVITY . α, β- AND γ-RAYS 539.16

539.16/.17

5591. Tables of coefficients for angular distribution analysis. W. T. SHARP, J. M. KENNEDY, B. J. SEARS AND M. G. HOYLE. *Atomic Energy Canada Rep.*, *No.* 97, 39 *pp.* (revised *Aug.* 4, 1954).

Tables of Z, Z_1, W and X coefficients are presented in factored form for a range of parameters appropriate to the needs of the Chalk River electrostatic accelerator. In particular these tables suffice for most double correlation experiments involving particles with orbital angular momentum not larger than 4, or dipole, quadrupole or octupole γ-radiation. Some of the coefficients are taken from previous tabulations while the remainder have been computed. An introductory section lists formulae for the correlation of nuclear radiations and the angular distribution of nuclear reaction products in terms of the tabulated coefficients. A.

539.16 : 546.797

5592. Actinium. R. W. CLARKE. *Atomic Energy Res. Establ.* [*Harwell*] *Inf. Bib.* 95, 24 *pp.* (1954).

A bibliography of 246 unclassified and declassified Atomic Energy Project reports, and references to the published literature (1906–53).

539.16.08

5593. Disintegration-rate determination by 4π-counting. I. B. D. PATE AND L. YAFFE. *Canad. J. Chem.*, **33**, *No.* 4, 610–32 (*April*, 1955).

The response probability of a 4π-counter has been examined and conditions determined for which the response probability is unity to within $\pm 0{\cdot}1\%$ for a range of nuclides. Variables examined have been the effect of polarization potential, discriminator bias, source location, counting rate, counter gas purity, thickness of conductor on source mount, for particles of various energies and from various modes of disintegration. A.

539.16.08

5594. An automatic monitor for measuring tritium contamination in air. D. F. SHAW. *J. sci. Instrum.*, **32**, *No.* 5, 178–80 (*May*, 1955).

The method of detection is based on the measurement of ionization in an air sample. A direct-reading meter registers the level of radioactivity and provision is made for operating a recorder. The instrument was

developed to test for tritium contamination but may be used to detect other airborne radioactive gases, e.g. $C^{14}O_2$ or radon. A.

539.16.08 : 519.2

5595. The statistical significance of very low counting rates. E. A. C. CROUCH. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. C/R* 1458, 7 *pp.* (1954).

The fiducial limits for the net activity are derived for the case where the background count is of the same order as the activity, and both are very low. A table of these limits is given together with illustrations of its use. A.

539.16.08 : 535.376

5596. Possibility of a nuclear radiation detector by means of electroluminescent phosphors. W. LOW. Letter in *Phys. Rev.*, **98**, *No.* 2, 556 (*April* 15, 1955).

539.163

5597. A new isobaric series 108 (110). G. B. BARÓ, P. REY AND W. SEELMANN-EGGEBERT. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 81–2 (1955) In German.

Provisional results on U fission products.

A. O. STANESBY

539.163

5598. Radioactive ^{69}As and ^{70}As. F. D. S. BUTEMENT AND E. G. PROUT. Letter in *Phil. Mag.*, **46**, 357–8 (*March*, 1955).

A new positron activity ($E_{\beta^+_{max}} = 2{\cdot}9$ MeV) with a ½-life of 15 min was obtained in the As fraction separated from proton-irradiated Ge, and assigned to As^{69}; in addition a single γ-ray of 0·23 MeV was found. The γ-spectrum of As^{70} (52 min) was also examined, and new lines found at 0·18 and 1·36 MeV.

A. O. STANESBY

539.163

5599. On the total decay energy in the orbital electron capture of ^{181}W. A. BISI, S. TERRANI AND L. ZAPPA. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 651–6 (*April*, 1955).

An investigation of the radiations from W^{181} was made by means of a high transmission β-spectrometer, a proportional counter spectrometer and a scintillation spectrometer. W^{181} was found to emit only *LX*- and *KX*-radiations, characteristic of Ta, arising from *L*- and *K*-capture. The decay energy was found to be: $E_0 = 92$ keV, and the transition was classified as once forbidden ($\Delta I = 0, 1$; yes). The pairing effect in the region around $A = 181$ from the Suess–Jensen plot is briefly discussed. A.

539.163

5600. Radioactive ^{184}tantalum. F. D. S. BUTEMENT AND A. J. POË. *Phil. Mag.*, **46**, 482–4 (*May*, 1955).

Ta^{184} has been produced and its decay characteristics determined as follows: half-life 8·7 ± 0·1 hr; β-energy (MeV) 0·15, 1·26; γ-energy (keV) 110, 160, 210, 240, 300, 405, 780, 890, 1180. The mass assignment was confirmed by its preparation by a (n, p) reaction on tungstic acid enriched in W^{184}. A.

539.163 : 539.166

5601. The decay of 175 and 177 ytterbium. H. DE WAARD. Letter in *Phil. Mag.*, **46**, 445–7 (*April*, 1955).

The β- and γ-radiations from Yb^{175} and Yb^{177} were studied by scintillation counters and β-spectrometers. Spin and multipole assignments are made from measurements of internal conversion coefficients, relative intensities and lifetimes of these radiations. The 395 and 281 keV γ-rays from Yb^{175} and that of 146 keV from Yb^{177} appear to be principally *E*1 transitions. M. A. GRACE

539.163 : 539.166

5602. Angular correlation of gamma rays in ^{175}Lu. L. ÅKERLIND, B. HARTMANN AND T. WIEDLING. Letter in *Phil. Mag.*, **46**, 448–9 (*April*, 1955).

The angular correlation of the 113 and 281 keV γ-rays following the β-decay of Yb^{175} was measured with scintillation counters as $W(\theta) = 1 + (0{\cdot}202 \pm 0{\cdot}012)P_2(\cos\theta)$. This result is discussed together with those of the preceding abstract. M. A. GRACE

539.163.1

5603. On the natural radioactivity of V^{50}, In^{113} and Te^{123}. J. HEINTZE. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 77 (1955) In German.

This was investigated using Geiger and proportional counters; within the exptl. error no evidence was found of any radioactivity, and minimum ½-lives deduced from the measurements are given.

A. O. STANESBY

539.163.1

5604. On the half-life of Y^{90}. P. SCHMELING. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 79 (1955) In German.

The Y^{90} was separated chemically from Sr^{90} impurity, and the activity followed over 20 days using an end-window G.M. counter. The ½-life was 64·2 ± 0·2 hr. A. O. STANESBY

539.163.1

5605. Fast *E*2 transitions. A. W. SUNYAR. *Phys. Rev.*, **98**, *No.* 3, 653–7 (*May* 1, 1955).

Lifetime measurements in the 10^{-9} sec range have been made for *E*2 or *M*1 + *E*2 transitions in the following nuclei: Sm^{152}, Gd^{154}, Hf^{180}, W^{182}, Os^{188}, Ir^{191}, Au^{197} and Po^{210}. Upper limits for lifetimes have been established for *E*2 or *M*1 + *E*2 transitions in Ir^{191}, Pb^{204}, Pb^{206}, Pb^{207} and U^{234}. *E*2 radiative transition probabilities are considered within the framework of the Bohr–Mottelson unified nuclear model. For neutron number $N = 90 - 126$, distortion parameters evaluated from *E*2 radiative lifetimes are about 5–6 times smaller than those evaluated from first-excited-state energies of even-even nuclei. A.

539.163.2

5606. Preliminary note on the disintegration of tungsten^{185}. A. M. MIJATOVIĆ. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **4**, 75–7 (*June*, 1954).

Preliminary measurements of the β- and electromagnetic spectra are in conflict with the scheme of Goldhaber and Hill [Abstr. 1022 (1953)].

A. O. STANESBY

539.163.2

5607. Radioactive decay of 65-hour Sb^{122}. M. J. GLAUBMAN. *Phys. Rev.*, **98**, *No.* 3, 645–52 (*May* 1, 1955).

65-hour Sb^{122} was investigated by using Sb^{121} (97·7–99·4%) that had been bombarded with thermal neutrons for 70 hours. Spectrometer measurements show three β-groups with end-point energies: 1·987, 1·423 and 0·734 MeV; and log *ft*

values: 8·6 [$\log ft(w^2 - mc^2) = 10{\cdot}0$, $p^2 + q^2$ shape], 7·6 (allowed shape) and 7·7; and four γ-rays with energies: 0·563, 0·693, 1·152 and 1·256 MeV; and intensities: 73%, 3·6%, 0·75% and 0·8%. From γ-γ and β-γ coincidences the excited states of Te^{122} were found at 0·563 and 1·256 MeV X-γ coincidences and X-ray critical absorption showed 2·2% and 0·8% K-capture transitions to the ground state and to a 1·152 MeV level in Sn^{122}. The ft values for the transitions to Sn^{122} are 13 times smaller than the corresponding transitions to Te^{122}. Annihilation radiation was not observed setting an upper limit of 0·005% for positrons. The directional correlation of the 0·693 and the 0·563 MeV γ-rays indicated a 2 — 2 — 0 cascade, with the 2 — 2 transition 91 + 5% quadrupole. The first excited state in Te^{122} was also shown to be 2+ from a measurement of the K conversion coefficient of the 0·563 MeV γ-ray. It is concluded therefore that the ground state of Sb^{122} is 2− ($g_{7/2}$, $h_{11/2}$), the first two excited states of Te^{122} are 2+, and the first excited state of Sn^{122} may also be 2+.

A.

539.163.2

5608. Energy levels of Se^{76} appearing in disintegration of As^{76}. J. D. KURBATOV, B. B. MURRAY AND M. SAKAI. *Phys. Rev.*, **98**, *No.* 3, 675–7 (*May* 1, 1955).

The radiations from As^{76} have been studied by means of a thick-lens magnetic spectrometer and a scintillation coincidence spectrometer. Five γ-rays of energies 0·55 MeV, 0·64 MeV, 1·20 MeV, 1·40 MeV and 2·05 MeV were observed by measurement of the photospectrum and they were fitted into a disintegration scheme with data obtained from γ-γ and β-γ scintillation coincidence measurements. The β-ray spectrum was measured and the data treated by Fermi plot analysis; the end point, branching ratio, and log ft values found for each β-ray component are as follows: 2·965 MeV, 2·41 MeV, 1·76 MeV and 0·36 MeV; 50·5%, 31·0%, 16·0% and 2·5%; 8·4, 8·2, 7·9 and 5·6, respectively. A.

539.163.2 : 539.166

5609. A new rhodium isotope (106[m]) with a half-life of 117 minutes. G. B. BARÓ, W. SEELMANN-EGGEBERT AND I. E. ZABALA. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 80 (1955) In German.

This was separated from neutron- and deuteron-irradiated Pd. The max. energy (Al absorption) is ~0·7 MeV (β^-), but there may be a weak component up to 0·95 MeV. Gamma-radiation amounts to ~4 MeV/β^--particle, and the γ-spectrum is highly complex. A. O. STANESBY

539.165

5610. The maximum [β-particle] energies of Xe^{138} and Xe^{137}. S. J. NASSIFF AND W. SEELMANN-EGGEBERT. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 87 (1955) In German.

These were measured using an arrangement designed to eliminate the effect of the daughter Cs activity. $E_{\beta max}$ for $Xe^{138} = 2{\cdot}4$; for $Xe^{137} = 3{\cdot}5$ MeV.

A. O. STANESBY

539.165.08

5611. Ionization of air by beta rays from point sources. R. K. CLARK, S. S. BRAR AND L. D. MARINELLI. *Radiology*, **64**, *No.* 1, 94–104 (*Jan.*, 1955).

Describes careful experiments in measuring β-rays from P^{32}, Tl^{204}, Y^{91} and RaE. A large room was used, and all effects due to solid scatterers or absorbers, the earth's magnetic field and air current movements were accounted for. The source was mounted in a thin Al disk. The response of a large gridded chamber (described in detail) is recorded by a vibrating reed electrometer and its variation with distance from the source is plotted. Corrections for deviations from the inverse square law are made because of the large dimensions of the ion chamber. Relative results are reliable to 2%, overall uncertainty to 5%. Results are in good agreement with Loevinger's calculations.

D. V. MABBS

539.166

5612. Life-time of the first excited state of Ni^{60}, Ba^{134}, Pd^{106} and Re^{185}. V. Z. WINTERSTEIGER. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **4**, 79–82 (*June*, 1954).

A delayed coincidence technique, with a lower limit of $\sim 5 \times 10^{-10}$ sec, was used. For Ni^{60}, Ba^{134} and Pd^{106}, the life-time $< 5 \times 10^{-10}$ sec; for Re^{185} $< 10^{-9}$ sec. A. O. STANESBY

539.166

5613. A 3·8 sec isomer Au^{193m}. J. BRUNNER, H. GUHL, J. HALTER AND O. HUBER. *Helv. phys. Acta*, **28**, *No.* 1, 85–8 (1955) In German.

An expected isomer Au^{193m} (11/2, −) was found as a decay product in proton-irradiated Au; the ½-life was 3·8 ± 0·3 sec and the isomer decays either directly or through an intermediate (5/2, +) level to the 16 hr isomer (3/2, +). A. O. STANESBY

539.166

5614. Gamma radiation from polonium neutron sources. R. J. BREEN AND M. R. HERTZ. *Phys. Rev.*, **98**, *No.* 3, 599–604 (*May* 1, 1955).

A NaI(Tl) crystal scintillation spectrometer was used to investigate the γ-spectrum from Po-α bombardment of Li, Be, B, F, Na, Mg and Al. The principal γ-energies observed were: Li, 0·483 MeV; Be, 4·45 MeV; B, 2·36 and 3·68 MeV; F, 1·28 and 1·51 MeV; Na, 1·83 and 2·57 MeV; Mg 1·30, 1·82 and 2·97 MeV; Al, 1·25, 2·28 and 3·55 MeV. The probable origin of the γ's is discussed. A.

539.166

5615. The construction and calibration of a 100-curie gamma irradiator. A. CHARLESBY AND O. FLINT. *Atomics* [*London*] **6**, *No.* 4, 100–7 (*April*, 1955).

The construction and operation of a γ-source (~100 curies) of flexible and simplified design, fuelled with radioactive cobalt, is described. Theoretical estimation of the activity intensity distribution of the source, when compared with experimental determinations of intensity by chemical tests confirms the calculated flux distribution. The absolute values of γ-intensity differ from those observed by 35 to 40%. A.

539.166.08

5616. Mapping radiation fields with silver-activated phosphate glass. H. RABIN AND W. E. PRICE. *Nucleonics*, **13**, *No.* 3, 33–5 (*March*, 1955).

Measurements on the radiation field of a large 2·5 kilocurie Co^{60} source, using the changes in optical densities of Ag-activated phosphate glass

exposed at various points in the field, are outlined. A procedure for correcting for the fading of coloration during irradiation is described. L. R. SHEPHERD

539.166.08 : 537.542

Measurement of gamma ray fluxes. *See Abstr.* 5477

539.166.2

5617. Statistical factors for electromagnetic transitions. J. M. KENNEDY AND W. T. SHARP. *Atomic Energy Canada Rep., No.* 139, 27 *pp.* (*Oct.*, 1954).

Using the algebra of tensor operators, expressions are obtained for the statistical factors for electromagnetic transitions of arbitrary multipolarity between one- and two-particle states. The modifications necessary if particles are replaced by holes or if motion of the core is taken into account are discussed briefly. A.

539.166.835

5618. Angular correlation of photons from positron annihilation in light metals. R. E. GREEN AND A. T. STEWART. *Phys. Rev.*, **98**, *No.* 2, 486–91 (*April* 15, 1955).

The angular correlation of γ-rays from positron annihilation in the light metals, Li, Be, Na, Mg, Al, K and Ca, has been measured. The deviation of the two photons from colinearity is a measure of the total momentum of the annihilating electron-positron pair. If it is assumed that the positrons are thermalized before annihilation and that they annihilate only with electrons of a Sommerfeld free electron gas, the experimental results may be used to determine the Fermi energy of these electrons. It is interesting that the Fermi energies so determined are in good agreement with calculated values. A.

539.167.3

5619. Aerial prospecting for radioactive deposits in snowfalls. E. A. GODBY, G. S. LEVY, H. CARMICHAEL, G. COWPER AND J. F. STELJES. *Atomic Energy Canada Rep., No.* 64, 13 *pp.* (*July*, 1951).

539.167.3

5620. A new method for extraction of radioactive phosphorus-32. K. SAMSAHL AND K. TAUGBÖL. *JENER Rep., No.* 35, 4 *pp.* (1955).

The principle of separating an isotope formed from the solid target material by diffusion, by utilizing a crystal change of the target, is here applied to the preparation of radioactive phosphorus-32. Irradiated, finely powdered sulphur is boiled with water containing a few drops of a suitable wetting agent. Owing to the transition point between rhombic and monoclinic sulphur at 95·5°C, the radioactive phosphorus will diffuse out of the solid material in 1–2 hr, and thus be extracted into the water. The yields depend greatly on the particle size of the sulphur, giving above 80% for finely ground material. Radiochemical analysis showed that the solution contained no other activities than phosphorus. Radioactive sulphur-35 thus remains in the target material. Spectrographic analysis showed a very pure product; no iron could be detected. The method requires only about 3 hr and the apparatus is very simple. It thus represents a convenient method for routine preparation of phosphorus-32 from pile irradiated sulphur. A.

NUCLEAR REACTIONS 539.17

539.17

5621. Concerning the Rutherford scattering formula. M. M. GORDON. *Amer. J. Phys.*, **23**, *No.* 5, 247–8 (*May*, 1955).

Working directly from the impulse-momentum theorem in combination with the angular momentum equation, Rutherford's formula is derived without making explicit use of the trajectories of the scattered particles. This derivation is noteworthy in that it specifically demonstrates the special nature of the inverse-square-law force in classical scattering theory. A.

539.17 : 537.591.8

An atlas of typical expansion chamber photographs. *See Abstr.* 5505

539.172

5622. On angular effects in nuclear reactions induced by unpolarized particles. C. D. HARTOGH, S. R. DE GROOT AND H. A. TOLHOEK. *Physica*, **21**, *No.* 4, 281–4 (*April*, 1955).

Explicit formulae are given for the angular distribution and angular correlation of radiation (particles or polarized γ-radiation) emitted by nuclei, which are formed by the capture of unpolarized particles by initial nuclei oriented at random. A.

539.172

Nuclear reactions due to cosmic rays. *See also under* "Cosmic rays." Decimal classification 537.591.8

539.172

5623. The interaction of fast *K*-mesons. M. W. FRIEDLANDER, D. KEEFE AND M. G. K. MENON. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 694–704 (*April*, 1955).

Two events are described in which heavy mesons interact with nuclei in photographic emulsions, producing small stars and emerging themselves from the collisions. In one example, a relativistic singly charged particle enters the stack and produces a star with only three emergent charged particles, which have been identified as a hyperon, a π-meson and a K-meson respectively. The K-meson creates two stars before it comes to rest and decays with the emission of a slow π-meson. In the other example, a K-meson enters the stack from outside and, after interacting, comes to rest within the emulsion and decays with the emission of a single lightly ionizing particle. Certain features of interest associated with the scattering properties of heavy mesons are discussed. A.

539.172.13

5624. Scattering of 4·9 MeV protons by ^{27}Al. K. B. MATHER. Note in *Austral. J. Phys.*, **7**, *No.* 4, 658–60 (*Dec.*, 1954).

The scattered protons were detected in photographic plates and the range spectrum measured. A graph is given of the range spectrum and from it excited states at 0·83, 1·01, 2·22 and 3·01 MeV above the ground state in Al^{27} deduced. An estimate of the differential cross-section at 45° is given for both the elastically and inelastically scattered protons. J. HUGHES

539.172.13

5625. Elastic scattering of polarized protons from complex nuclei. J. M. Dickson, B. Rose and D. C. Salter. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 361–8 (*May*, 1955).

The degree of polarization obtained when approximately 130 MeV protons are scattered from Be, C, Al, Fe, Ag, Cd, Bi and U has been studied as a function of the laboratory scattering angle from 10 to 45°. Irregularities in the patterns so obtained may be associated with the diffraction patterns of the elements concerned. The degree of polarization from Be and C has been found to fall rapidly as the proton energy is reduced below 130 MeV. A.

539.172.13

5626. Angular distributions and angular correlations in the reaction $^{23}Na(p,\gamma)^{24}Mg$. P. J. Grant, J. G. Rutherglen, F. C. Flack and G. W. Hutchinson. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 369–76 (*May*, 1955).

The angular distributions and angular correlations of the more intense γ-ray components have been determined at four resonances. Those at proton energies of 310 keV, 515 keV and 679 keV are assigned $J=2^-$, $J=1^+$ and $J=3^+$ formed by p-, s- and d-wave protons respectively. The resonance at 593 keV has $J=2^-$ formed by p-wave protons and is therefore distinct from that in the (p,α) reaction at this energy. The level in Mg^{24} at 4·24 MeV is assigned $J=2^+$ and that at 5·26 MeV $J=3$, probably with odd parity. A.

539.172.13

5627. Deuteron stripping and the collective nuclear model. G. R. Satchler. Letter in *Phys. Rev.*, **97**, *No.* 5, 1416–17 (*March* 1, 1955).

Formulae for the reduced widths for capture into nuclear rotational levels are given. G. E. Brown

539.172.13

5628. Angular distributions from (d, n) reactions at 0·86 MeV deuteron energy. L. L. Green, J. P. Scanlon and J. C. Willmott. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 386–92 (*May*, 1955).

The angular distributions of neutron groups from the reactions $Be^9(d,n)B^{10}$ and $C^{13}(d,n)N^{14}$ have been measured for a deuteron energy of 0·86 MeV. The excitation energies of the first few excited states of B^{10} and N^{14} have been measured, and are in good agreement with previous measurements. The angular distributions have been analysed in terms of both compound nucleus and stripping interactions. Only the fourth excited state of B^{10} and the third excited state of N^{14} were found to be formed to a large extent by deuteron stripping. A.

539.172.13

5629. An investigation of $^7Li(d,n)^8Be$ and $^{11}B(d,n)^{12}C$ nuclear reactions. M. A. Ihsan. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 393–7 (*May*, 1955).

The energy levels of Be^8 and C^{12} have been studied by means of the (d, n) reaction using deuterons of energy 686 keV. Evidence of levels in Be^8 was found at 2·98 and 7·53 MeV. Investigation of energy levels of C^{12} has shown energy peaks at 4·40, 7·63 and 9·72 MeV respectively. The angular distribution of neutrons from the $B^{11}(d,n)C^{12}$ reaction also has been investigated. A.

539.172.13

5630. Experimental determination of the absolute differential cross sections for the $O^{16}(d,p)O^{17}$, $O^{16}(d,p)O^{17*}$, and $O^{18}(d,p)O^{19*}$ reactions. T. F. Stratton, J. M. Blair, K. F. Famularo and R. V. Stuart. *Phys. Rev.*, **98**, *No.* 3, 629–34 (*May* 1, 1955).

Nickel oxide foil targets were bombarded with deuterons in order to study the angular distributions of protons from the $O^{16}(d,p)O^{17}$ (ground state), $O^{16}(d,p)O^{17*}$ (0·875 MeV level), and $O^{18}(d,p)O^{19*}$ (1·468 MeV level) reactions. The absolute yield of the $O^{16}(d,p)O^{17}$ ground-state reaction was measured at $\theta_{c.m.}=53°$ in 35 keV steps of laboratory deuteron energy from 2·3 MeV to 3·9 MeV. A resonant-type yield was obtained, with cross-sections per unit solid angle at $\theta_{c.m.}=53°$ of 17 mb at 2·65 MeV, 33 mb at 3·01 MeV, 19 mb at 3·25 MeV and 31 mb at 3·43 MeV. Angular distributions obtained over twenty-two centre-of-mass angles from 5 to 161° at these four deuteron energies showed a forward maximum at 53° falling to a minimum of 13 mb in the neighbourhood of 90° and rising gradually to 16 mb in the back angles. Fluctuations of intensity at the forward maximum provided the major contribution to maxima in the total yield at 3·0 MeV and 3·4 MeV. Differential cross-sections for the $O^{16}(d,p)O^{17*}$ (0·875 MeV level) were measured at incident deuteron energies of 3·01 MeV and 3·43 MeV. The distributions obtained were of the typical stripping type with $l_n=0$. With NiO targets enriched to 23% in O^{18}, an angular distribution was obtained with 3·01 MeV deuterons for the $O^{18}(d,p)O^{19*}$ (1·468 MeV level) reaction. The distribution was of the character of a typical $l_n=0$ type stripping distribution with cross-sections of 213 mb at 5°, falling to a minimum of 11 mb at 48° and rising to a secondary maximum of 27 mb at 84°. A spin and parity assignment of $\frac{1}{2}$, + to the 1·469 MeV level in O^{19} was made on the basis of the observed distribution. A.

539.172.13

5631. Low-energy protons from targets bombarded by 15-MeV deuterons. F. A. Aschenbrenner. *Phys. Rev.*, **98**, *No.* 3, 657–65 (*May* 1, 1955).

A particle-selection technique is described which makes it possible to identify readily the reaction particles from deuteron-induced reactions. The results of a study of the low-energy protons from targets bombarded by 15 MeV deuterons is presented. The proton energy spectra from niobium, silver, antimony, tantalum, three lead isotopes and uranium bombarded with the direct deuteron beam were observed at several angles. In addition, the proton energy spectrum from tantalum was observed at several deuteron beam energies ranging from approximately 10·5 to 15 MeV. The low-energy parts of the proton spectra show what appears to be a Coulomb barrier effect. However, protons are observed several MeV below the Coulomb barrier for protons, indicating that the barrier effect differs from the ordinary Coulomb barrier penetration of protons emerging from a compound nucleus. The behaviour of the barrier effect with respect to changes in counter angle, Z (atomic number), and A (mass number) of the targets, and deuteron beam energy was observed. A.

539.172.13 : 537.534.74

5632. Deuteron-helium differential scattering cross sections. A. Galonsky, R. A. Douglas, W. Haeberli, M. T. McEllistrem and H. T. Richards. *Phys. Rev.*, **98**, *No.* 3, 586–90 (*May* 1, 1955).

Deuteron-helium elastic scattering cross-sections have been measured from $E_d = 0{\cdot}28$ to $4{\cdot}62$ MeV. A resonance at $E_d = 1{\cdot}070$ MeV and $\Gamma \sim 35$ keV was observed at 9 angles from 90 to 173·6° c.m. This resonance corresponds to the previously observed $2{\cdot}187$ MeV state of Li^6. No scattering anomaly was observed at the deuteron energy corresponding to the known $3{\cdot}58$ MeV level of Li^6. This negative result is consistent with an assignment of $J = 0^+$, $T = 1$ to this state. A very broad scattering anomaly is observed from about 3 MeV to $4{\cdot}62$ MeV. Most of the cross-section measurements are good to 3% or better in absolute magnitude. A.

539.172.13 : 537.534.74

5633. Energy levels of Li^6 from the deuteron-helium differential cross sections. A. Galonsky and M. T. McEllistrem. *Phys. Rev.*, **98**, *No.* 3, 590–9 (*May* 1, 1955).

The deuterium-helium differential cross-sections reported in the preceding abstract have been analysed in terms of a dispersion formalism to classify energy levels of Li^6. A level at $E_x = 2{\cdot}185$ MeV is confirmed to be a single-particle, 3^+, $T = 0$ level. The broad anomaly extending from 3 MeV to the limit of observation, $4{\cdot}62$ MeV, cannot be analysed in terms of a single level. Instead, it has been fitted with two single-particle levels, a 2^+ level at $E_x = 4{\cdot}53$ MeV in Li^6 and a 1^+ level at $5{\cdot}4 \pm 0{\cdot}5$ MeV. The 1^+ level cannot be located more accurately because only the tail is visible at the bombarding energies available. All of the other two-level combinations have been ruled out. The assignments, (3^+, 2^+, 1^+), and locations of the levels agree with an intermediate coupling model which is close to the $L-S$ extreme. In the neighbourhood of and above the 3^+ resonance the usual hard-sphere phase shifts, which are always negative, cannot be used for the P-wave. This result may indicate odd-parity states above the presently investigated energy region. For the other partial waves, hard-sphere phase shifts corresponding to radii anywhere from 3 to 5×10^{-13} cm were satisfactory, provided the reduced width of the ground state of Li^6 was simultaneously varied from the Wigner limit to very small values. A.

539.172.3

5634. Photoprotons from lead-208 and tantalum. M. E. Toms and W. E. Stephens. *Phys. Rev.*, **98**, *No.* 3, 626–8 (*May* 1, 1955).

The photoprotons ejected from thin foils of tantalum and enriched lead-208 by the 23 MeV bremsstrahlung X-rays from a betatron have been observed in nuclear emulsions. Yields, measured in units of 10^4 protons per mole per roentgen unit, are: tantalum, $5{\cdot}6 \pm 0{\cdot}5$; lead-208, $2{\cdot}6 \pm 0{\cdot}3$. The angular distribution of the lead-208 protons shows a strong forward asymmetry while the tantalum protons are more isotropic. Both proton-energy distributions are in good agreement with the predictions of the direct photoprocess. A.

539.172.3 : 539.185

Neutron production by secondary gamma-ray flux in electron-bombarded uranium. *See Abstr.* 5656

539.172.4

5635. Energy levels of ^{56}Fe and ^{27}Al by the inelastic scattering of 15 MeV neutrons. R. Ramanna, N. Veeraraghavan and P. K. Iyengar. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 623–8 (*April*, 1955).

A stilbene scintillation spectrometer was used to study the neutrons inelastically scattered by iron and aluminium for an incident monoenergetic beam of 15 MeV neutrons. Using good geometry counts were taken with and without the scatterer in position and the results were analysed by a ratio method. For iron, levels have been obtained at 7·6, 5·8, 4·5 and 1·9 MeV. For aluminium, levels have been obtained at 8·1, 5·8, 4·0 and 3·0 MeV. Comparison with existing data from γ-ray measurements is given. A.

539.172.4

5636. Measurement of scattering cross sections for low-energy neutron resonances. C. Sheer and J. Moore. *Phys. Rev.*, **98**, *No.* 3, 565–78 (*May* 1, 1955).

The thick-target method for the measurement of the ratio of total to scattering cross-section for low-energy neutrons as a function of energy has been extended to include semi-thick targets. A family of calibration curves has been developed by means of which the measured scattered count may be interpreted in terms of (σ_s/σ_t) in the range 0–1. The 5·19 eV and 16·6 eV levels of silver have been investigated by this method. The data agree very well with a Breit–Wigner shape over a wide range centred at the resonance, although slight deviations can be noted at distance $> \sim 10\Gamma$ away from resonance. The scattering measurements yield three independent ratios between various groups of the Breit–Wigner parameters. These ratios may be used together with transmission data to calculate the parameters. The results obtained for silver are for the 5·19 eV level: $\Gamma = 0{\cdot}128$ eV, $\Gamma_n = 0{\cdot}0155$ eV, $\sigma_{t0} = 22\,200$ barn, $R_{J-1} = 0{\cdot}66$ barn$^{\frac{1}{2}}$; for the 16·6 eV level: $\Gamma = 0{\cdot}110$ eV, $\Gamma_n = 0{\cdot}039$ eV, $\sigma_{t0} = 7300$ barn, $R_{J-0} = 1{\cdot}10$ barn$^{\frac{1}{2}}$; σ_p (normal element) = 5·90 barn. A.

539.172.4

5637. Liquid scintillator measurements of angular elastic scattering of neutrons from carbon, aluminium, and sulfur. R. N. Little, Jr, B. P. Leonard, Jr, J. T. Prud'homme and L. D. Vincent. *Phys. Rev.*, **98**, *No.* 3, 634–9 (*May* 1, 1955).

Angular elastic scattering cross-sections have been measured for carbon, aluminium, and sulphur using 2·7 MeV neutrons from the D(d,n) reaction. A liquid organic scintillator, terphenyl in xylene, was used as the neutron detector. The differential pulse-height spectra for the neutrons scattered from sulphur and for Co^{60} γ-rays are given. A.

539.172.4

5638. Gamma radiation from neutron inelastic scattering. G. L. Griffith. *Phys. Rev.*, **98**, *No.* 3, 579–82 (*May* 1, 1955).

Energy measurements have been made by means of a scintillation spectrometer of the γ-rays produced by bombarding several elements with 4·5 MeV neutrons. The following γ-rays have been found

(energies in MeV): B: 0·70, 2·20; F: 1·34, 6·10; Al: 0·84, 1·02, 2·27, 3·10; Fe: 0·85, 1·20, 1·73, 2·05, 2·50, 3·52; Zr: 0·92, 2·20, 3·23; Pb: 0·79, 1·36, 2·70. These energy values can be used to determine accurate values of the nuclear energy levels for those elements where the level scheme has been determined uniquely by observations on the scattered neutron energy spectrum. A.

539.172.4

5639. Scattering of 4·4-MeV neutrons by iron and carbon. B. Jennings, J. Weddell, I. Alexeff and R. L. Hellens. *Phys. Rev.*, **98**, *No.* 3, 582–5 (*May* 1, 1955).

The results of photographic measurements of the neutron spectrum from the scattering at 90° of 4·4 MeV neutrons by iron have been combined with measurements of the energies of de-excitation γ-rays from the same process, as reported in the preceding abstract, to give values for the energy levels excited in Fe^{56}. The $(d\sigma/d\Omega)_{90°}$ for the various processes have been estimated from the areas under the peaks in the histogram. The energy levels and corresponding $(d\sigma/d\Omega)_{90°}$ for Fe^{56} are: elastic $0·076 \pm 0·02$ barn/sterad; inelastic $0·85 \pm 0·02$ MeV, $0·036 \pm 0·010$ barn/sterad; $2·05 \pm 0·036$ MeV, $0·021 \pm 0·007$ barn/sterad; $2·58 \pm 0·054$ MeV, $0·012 \pm 0·006$ barn/sterad; 2·90 MeV, $0·020 \pm 0·013$ barn/sterad. Similar measurements on carbon resulted in a $(d\sigma/d\Omega)_{90°}$ for the elastic process of $0·016 \pm 0·016$ barn/sterad. A.

539.172.4

5640. Parameters for the neutron resonance in gold. R. E. Wood, H. H. Landon and V. L. Sailor. *Phys. Rev.*, **98**, *No.* 3, 639–45 (*May* 1, 1955).

A highly detailed study of the 4·906 eV neutron resonance in Au^{197} has been made for the purpose of establishing preliminary values for a "standard" resonance. Such a standard can serve as a basis for comparing results from various neutron spectrometers and should assist in reducing large discrepancies in resonance parameters which now exist. The new measurements were made on a crystal spectrometer with unusually good resolution. Methods of "shape analysis" were used to fit the data to the one-level formula and the following parameters were obtained: $E_0 = 4·906 \pm 0·010$ eV; $\sigma_{t0}\Gamma^2 = (725 \pm 15) \times 10^{-24}$ cm^2.eV^2; $\sigma_{t0} = (37\,000 \pm 500) \times 10^{-24}$ cm^2; $\Gamma = 0·140 \pm 0·003$ eV; and $\sigma_p = (11·1 \pm 0·8) \times 10^{-24}$ cm^2. The one-level formula with these parameters gives an accurate fit to the data over the entire energy range from 0·35 to 15 eV. The nuclear radii corresponding to the two possible spin orientations of the incident neutron were found to be the same to within experimental error. A.

539.172.4

5641. Total cross section of deuterium for neutrons from 0·2 to 22 MeV. J. D. Seagrave and R. L. Henkel. *Phys. Rev.*, **98**, *No.* 3, 666–9 (*May* 1, 1955).

Transmission measurements of the total neutron cross-section of deuterium have been made with an accuracy of about 2% at 29 energies between 0·2 and 22 MeV, using deuterium gas in a cell 1 metre long. The cross-section decreases monotonically with increasing energy, and its reciprocal appears to be a linear function of neutron energy over the interval from 1·5 to 22 MeV: $\sigma = 14·35\ (E_n + 3·6\,\text{MeV})^{-1}$ barn. A.

539.172.4

5642. Elastic scattering angular distributions of fast neutrons on light nuclei. H. B. Willard, J. K. Bair and J. D. Kington. *Phys. Rev.*, **98**, *No.* 3, 669–73 (*May* 1, 1955).

New measurements of the total cross-section of Be^9 (resolution 4 keV) give maxima of $7·75 \pm 0·20$ barn ($\Gamma = 25$ keV) and $5·25 \pm 0·20$ barn ($\Gamma = 8$ keV) for the 0·62 MeV and 0·81 MeV resonances, consistent with $J = 3$ and $J = 2$ for the respective compound state spin values. Elastic scattering angular distributions indicate that the 0·62 MeV resonance may be formed by p-wave neutrons with the s-wave potential scattering ($\delta_0 = -54·2°$) spin-dependent and all channel spin 1, or possibly by d-wave neutrons with the resonance scattering all channel spin 2. Potential scattering phase shifts for B^{10} are $\delta_0 = -53·5°$ at 0·55 MeV; $\delta_0 = -60·7°$, $\delta_1 = -4·0°$ at 1·00 MeV; and $\delta_0 = -66·9°$, $\delta_1 = -10·3°$ and $\delta_2 = -2·9°$ at 1·50 MeV. The 0·43 MeV resonance in B^{11}, agrees with a $J = 2$, $l = 1$ assignment, while the 1·28 MeV resonance is best fitted by $J = 3$, $l = 2$; with a mixing ratio of channel spin 2 equal to 10 times channel spin 1. Potential scattering is nearly all s-wave up to 1·50 MeV where $\delta_0 = -90°$. C^{12} has pure s-wave scattering at 0·55 MeV ($\delta_0 = -50·1°$) and 1·00 MeV ($\delta_0 = -68·9°$), and at 1·50 MeV a small amount of p-wave appears ($\delta_0 = -79·4°$, $\delta_1 = -5·7°$). In general the observed s-wave phase shifts are larger than those calculated from a hard sphere model, whereas the p- and d-wave phase shifts are smaller. A.

539.172.4

5643. Interaction of 4·1-MeV neutrons with nuclei. M. Walt and J. R. Beyster. *Phys. Rev.*, **98**, *No.* 3, 677–84 (*May* 1, 1955).

The differential cross-sections for elastic scattering of 4·1 MeV neutrons by Be, C, Al, Ti, Fe, Zn, Zr, Cd, Sn, Ta, W, Au, Pb and Bi were measured using a biased scintillation detector with thresholds at about 2·0, 2·6 and 3·2 MeV. Multiple scattering corrections were made by an approximate method, the accuracy of which was investigated by Monte Carlo calculations. Inelastic collision cross-sections and elastic transport cross-sections were computed from the data. The experimental results are compared with theoretical cross-sections calculated using the complex square-well potential of Feshbach, Porter and Weisskopf. A.

539.172.4

5644. On the interpretation of fission asymmetry according to the liquid drop nuclear model. U. L. Businaro and S. Gallone. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 629–43 (*April*, 1955).

The possibility is examined, on the liquid drop-model, that the asymmetrization in low energy nuclear fission may take place after the system, in evolving along its reaction path, has passed the symmetric saddle. The energy surface is investigated beyond the symmetric saddles both by extrapolating well-known formulae, valid in the small deformation range, and by using a representation in which the energy of shapes slightly different from an arbitrarily prolated basic ellipsoid may be calculated. The results

obtained seem to indicate that along the effective symmetric reaction path there exists an "inversion" point, beyond which, in the case of incipient motion, a small asymmetric deformation would tend to grow. A.

539.172.4

5645. The variation of power in a fast reactor for a linear increase of reactivity. J. J. SYRETT. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. RP/M47*, 6 *pp.* (1954).

An approximate solution is derived for the variation of power in a reactor, containing a neutron source, in which the reactivity is increasing at a constant rate. It is assumed that all delayed neutron emitters have the same decay constant, and that the prompt neutron lifetime is negligibly small. It is shown for a numerical example that the error due to these assumptions is small. A.

539.172.4

5646. The variation of neutron flux with number of fuel elements in the approach to criticality of Zephyr. J. J. SYRETT. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. RP/M46*, 6 *pp.* (1954).

An expression is derived by diffusion theory for the neutron flux in a subcritical reactor consisting of a reflected cylindrical core containing a neutron source. By applying this expression to a model of Zephyr, it is shown numerically that for a fixed source at the centre of the core, the square root of the number of fuel elements in the core divided by the neutron flux at a fixed point in the reflector, plotted as a function of the number of fuel elements, is approximately a straight line when more than half the critical number of fuel elements are present. The results are compared with those obtained during the approach to criticality of Zephyr. A.

539.172.4

5647. The energy spectrum of neutrons reflected from a moderator. K. T. SPINNEY. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M120*, 11 *pp.* (1955).

Analytic expressions are derived for the energy spectrum of neutrons emerging from a moderating medium which is being irradiated by fast neutrons. Some examples are given for the case of concrete. A.

539.172.4

5648. Reprocessing reactor fuels. H. A. OHLGREN, J. G. LEWIS AND M. WEECH. *Nucleonics*, **13**, *No.* 3, 18–21 (*March*, 1955).

The solvent extraction process for separating U and Pu from fission products is outlined with particular reference to the use of pulse plate columns. Estimates are given of the costs of processing irradiated uranium to recover Pu + U or the separated fissile isotopes. Other processing methods are mentioned briefly.

L. R. SHEPHERD

ATOM AND MOLECULAR BEAMS . MESONS NEUTRONS 539.18

539.18

5649. Nuclear absorption of a fast charged hyperon. M. M. BLOCK AND D. T. KING. Letter in *Phys. Rev.*, **97**, *No.* 5, 1415–16 (*March* 1, 1955).

Discusses a star observed in G5 emulsion which is interpreted as being a possible example of the nucleonic absorption in flight of a charged hyperon according to the scheme $Y^{\pm} + p \rightarrow p + K^{\pm} + n$.

H. ELLIOT

539.18

5650. K-mesonic decay of a slow secondary particle. W. F. FRY, J. SCHNEPS AND M. S. SWAMI. Letter in *Phys. Rev.*, **97**, *No.* 4, 1189–90 (*Feb.* 15, 1955).

539.18

5651. On the masses of mesons and hyperons. K. M. GATHA. Letter in *Curr. Sci.*, **23**, *No.* 12, 392–3 (*Dec.*, 1954).

Masses are postulated to be integral multiples of a basic mass. G. E. BROWN

539.18

5652. Notes on the energy spectra and frequencies of production of V^0-particles. D. B. GAYTHER AND C. C. BUTLER. *Phil. Mag.*, **46**, 467–81 (*May*, 1955).

An analysis is made of the decays of 45 V^0-particles associated with nuclear interactions in a lead plate mounted inside a cloud chamber. Data are given on the energy spectra of the Λ^0- and θ^0-particles and possible sources of experimental bias are discussed. Distributions are also given of ϕ, the angle between the path of the primary of the interaction in which a V^0-particle is produced and the line of flight of the V^0-particle in the laboratory frame of reference. The ϕ-distribution for Λ^0-particles is found to be similar to that of the grey particles produced in nuclear interactions while that for the θ^0-particles is similar to the angular distribution of the shower particles. Both Λ^0- and θ^0-particles are found to occur at frequencies of about 3·0% of the charged π-mesons in nuclear interactions of mean energy (5–10) BeV. A discussion is given of the data in terms of possible modes of production. A.

539.185

5653. Multi-group theory with an application to inelastic scattering in uranium. M. E. MANDL. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. T/R1500*, 11 *pp.* (1954).

A multi-group theory is given for systems where energy losses covering more than one energy group can occur at single collisions, e.g. by inelastic scattering or by elastic scattering in hydrogenous mixtures. Several different types of boundary conditions are considered and the system need not be self-critical. The theory is illustrated by applying it to calculating the energy spectra at various distances from a point source in a large block of natural uranium. A.

539.185

5654. Neutron density in an infinite, non-capturing medium surrounding a long cylindrical body which scatters and captures neutrons. S. A. KUSHNERIUK AND C. MCKAY. *Atomic Energy Canada Rep.*, *No.* 137, 68 *pp.* (*July*, 1954).

The asymptotic neutron density in a purely scattering medium of infinite extent into which is inserted an infinitely long cylinder which scatters and captures neutrons is derived from the integral equation defining the density using as a basis a variational procedure, perturbation methods (for cylinders of small and large radii) and Weiner-Hopf type of analysis (for cylinders of infinitely large radii). It is assumed that the

neutron sources are infinitely far from the cylindrical body and that the scattering in the medium surrounding the cylinder is elastic and isotropic. It is known that under these conditions the form of the space dependence of the asymptotic neutron density distribution coincides with the form of the solution for the density distribution in the diffusion approximation and thus a knowledge of the correct asymptotic neutron density distribution effectively provides a boundary condition for the diffusion differential equation. Specifically, the following varieties of media comprising the cylindrical body are considered: (1) The cylindrical body is homogeneous and captures neutrons only, (2) as in (1) with the addition of scattering. (3) The cylindrical body is composed of a homogeneous inner region which captures neutrons only, and which is surrounded by an air-gap or a thin, weakly absorbing sheath or both, (4) as in (3) with the addition of scattering in the inner medium. A.

539.185

5655. Moderation of neutrons in SiO_2 and $CaCO_3$. J. Tittman. *J. appl. Phys.*, **26**, *No.* 4, 394–8 (*April*, 1955).

The spatial distributions of indium resonance neutrons about a "point" Ra–Be source have been measured in pure $CaCO_3$ (limestone) and SiO_2 (sand) out to $r^2 \simeq 9\tau$. Both media show nearly Gaussian distributions corresponding to Fermi ages $\tau(SiO_2) = 1\,906 \pm 90\,cm^2$ and $\tau(CaCO_3) = 461 \pm 23\,cm^2$ over most of the range observed. Excess resonance flux near the source, more pronounced in $CaCO_3$ than in SiO_2, appears to be due to inelastic scattering although such interpretation is not unambiguous. Space integrals indicate ~10% more absorption in $CaCO_3$ than in SiO_2 during moderation. Data were corrected for 4·5 hr activity, 54 min activation by high energy neutrons, and edge effects; consideration was given to the 3·9 and 9 eV In levels in defining the mean detection energy and to the non-monoenergetic nature of the Ra–Be source in affecting the shape of the indium resonance spatial distribution. A.

539.185 : 539.172.3

5656. Neutron production of electron bombardment of uranium. M. B. Biram. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. T/R*1523, 8 *pp.* (1954).

An attempt is made to calculate the number of neutrons produced per electron, when a monoenergetic beam of electrons is allowed to fall on a thick uranium traget. A Monte Carlo process is used to determine the spectrum of γ-rays in the target as a result of primary processes. The effect of secondary processes is then calculated from this information. Initial electron energies between 30 and 40 MeV are considered. A.

539.185

5657. Magnetic scattering of slow neutrons by gaseous oxygen. H. Palevsky and R. M. Eisberg. *Phys. Rev.*, **98**, *No.* 2, 492–4 (*April* 15, 1955).

The scattering of neutrons by oxygen was measured as a function of wavelength from 2·5–10 Å. By subtracting the calculated nuclear contribution the magnetic scattering is established. The magnitude of the magnetic interaction at long wavelengths is found to be in agreement with the theory of Halpern and Johnson. The measurement is not very sensitive to the details of the spatial distribution of the magnetic electrons. However, the observed wavelength dependence of the magnetic scattering is in agreement with the calculations of Kleiner based on the oxygen wave-function derived by Meckler. A.

539.185

5658. Neutron-proton scattering at small angles. J. J. Thresher, R. G. P. Voss and R. Wilson. *Proc. Roy. Soc. A*, **229**, 492–509 (*May* 24, 1955).

Neutron-proton scattering has been measured from 6 to 61·5° c.m. for neutrons of effective energy 105 ± 3 and 137 ± 5 MeV using a liquid hydrogen scatterer and a large neutron counter. The results confirm previous measurements and show a near symmetry around 90° at 105 MeV, and a fairly definite asymmetry at 137 MeV. The "Serber force" does not, therefore, give a good approximation to the experimental data at 137 MeV. A.

539.185.08

5659. The use of a lithium iodide detector with a neutron crystal spectrometer. K. P. Nicholson and N. J. Pattenden. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. NP/M*73, 4 *pp.* (1955).

The counting and background rates of a lithium iodide scintillation detector and a boron trifluoride proportional counter are compared when used as detectors for a neutron crystal spectrometer. The counts-to-background ratio of the scintillator is found to be considerably less than that of the proportional counter. The efficiency of the crystal, relative to the proportional counter, is compared with theoretical values. A.

539.185.08

5660. Portable survey meter for fast and slow neutrons. B. W. Thompson. *Nucleonics*, **13**, *No.* 3, 44–6 (*March*, 1955).

The instrument employs two proportional counters, one with BF_3 for slow neutron detection and the other containing a thick Polythene radiator to detect fast neutrons by proton recoils. The design and operating characteristics of these counters are described and some details of the associated circuit given. L. R. SHEPHERD

539.185.08

5661. Semiconductor fast-neutron dosimeter. B. Cassen, T. Crough and H. Gass. *Nucleonics*, **13**, *No.* 3, 58, 60 (*March*, 1955).

The use of germanium single crystals to measure fast neutron fluxes, on the basis of the change in electrical conductivity under irradiation, was investigated. The method of preparing and assembling the crystals is described and preliminary results on the response of these detectors is given. L. R. SHEPHERD

539.185.08 : 537.542

Proportional neutron counters. *See Abstr.* 5466

539.185.7

5662. Oscillator apparatus for the measurement of thermal neutron absorption cross-sections in B.E.P.O. V. G. Small and A. H. Spurway. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. RP/R*1439, 7 *pp.* (1954).

The apparatus differs from the more orthodox

type of pile oscillator, in that a local flux depression is measured, as opposed to an overall change in reactivity of the pile. A.

539.185.9

5663. Neutron irradiation effects in Cu and Al at 80°K. A. W. McReynolds, W. Augustyniak, M. McKeown and D. B. Rosenblatt. *Phys. Rev.*, **98**, *No.* 2, 418–25 (*April* 15, 1955).

A cryostat is described for pile neutron irradiation in the BNL reactor of samples at liquid nitrogen temperature. One-month irradiation resulted in resistivity increases of 20 and 33% for Cu and Al, respectively, at 80°K, and increases by about a factor of 5 in critical shear stress for both. Subsequent studies of the kinetics of recovery processes were made by a number of isothermal annealing curves at various temperatures from −80°C to 500°C. In copper, two-thirds of the resistivity effect anneals out from −80° to 20°C, activation energy ~0·6 eV, with no decrease in critical shear stress effect. Both effects then anneal together near 320°C, with energy 2 eV. In aluminium, both effects completely anneal out together near −60°, with 0·55 eV energy. Data are correlated with diffusion activation energy for lattice defects. A.

STRUCTURE OF SOLIDS 539.2

539.213

5664. Atomistic interpretation of the effect of the composition on the viscosity of glass. E. C. Marboe and W. A. Weyl. *J. Soc. Glass Technol.*, **39**, 16 T–36 T (*Feb.*, 1955).

In this paper earlier work on the low-temperature viscosity of simple glasses of widely-different chemical composition is reviewed, and the results are explained on the basis of the properties of ions and their interaction. It was found that a physical picture of the viscous flow of glasses can be obtained only if the interaction of the atoms to a considerable depth is taken into consideration. Among the current approaches to the nature of chemical binding forces, only the concepts of K. Fajans lend themselves to the development of a physical picture of such a "depth-action." This result can be generalized with respect to other mechanical properties of substances as determined by their chemical compositions. The response of matter to mechanical forces must change drastically if the volume under stress decreases below a certain critical value. Viscosity and strength should increase in the same fashion as the surface energy or the adhesion properties if the volume under test becomes too small for a co-operation of atoms over large volumes. This conclusion may be expressed in another form. If a condensed system is subjected to mechanical forces which tend to sever the chemical binding forces between two hypothetical planes of atoms, a large number of adjacent atoms co-operate with the mechanical forces by developing dipole moments, the forces of which aid the separation of the two hypothetical planes. A.

539.217

5665. Nuclear magnetic resonance evidence of self-diffusion in molecular solids. E. R. Andrew. *Defects in crystalline solids* [*Bristol*] 60–4. See Abstr. 5707 (1955).

It is shown that the narrowness of the nuclear magnetic resonance spectra for certain molecular solids at temperatures approaching their melting points indicates that the molecules are diffusing through the crystal. The activation energy for the process is in reasonable agreement with that expected for a vacancy mechanism of diffusion. A list is given of molecular compounds whose resonance spectra indicate self-diffusion, and reasons are advanced for the absence of this molecular motion in other solids. The effect of the diffusion on spin-lattice relaxation is also discussed. A.

539.217

5666. Diffusion of matter in solid metals and alloys. C. P. Chatterjee. *Indian J. theor. Phys.*, **2**, *No.* 2, 69–78 (*Sept.*, 1954).

From Fick's law of diffusion it may be easily shown that the rate of diffusion $(\delta\mu/\delta t)_i$ of the ith component in a system of q components is given by $(\delta\mu/\delta t)_i = \sum_{q=1}^{n} - {}_cD_{iq}\nabla C_q$, for $i = 1, 2, \ldots n$, and where $(\delta\mu/\delta t)$ is the mass of matter diffusing per unit area in unit time, ${}_cD_{iq}$ represent in general concentration–diffusion coefficients and ∇C_q is the concentration gradient of the qth component. To overcome the limitations of the above relation different assumptions have been made by different investigators on the basis of different thermodynamic functions like chemical potential, activity and fugacity leading to the equation $(\delta\mu/\delta t) = -\alpha D(\delta\alpha/\delta x)$ along some arbitrarily chosen x−axis. Similarly $(\delta\mu/\delta t) = -{}_fD(\delta f/\delta x)$ and $(\delta\mu/\delta t) = -G_kT[1 + (\delta\ln\lambda/\delta\ln c)](\delta c/\delta x)$, where ${}_\alpha D$, ${}_fD$ are the activity and fugacity diffusion coefficients, G is the mobility (velocity per unit force), k is the Boltzmann constant, T is the absolute temperature and λ is the activity coefficient. An attempt has been made in this paper to develop the concept of diffusion on the basis of potential ϕ and energy density ψ leading to the equation

$$\frac{\delta\mu}{\delta t} = -{}_\psi D\phi A\left[\left(\lambda + c\frac{\delta\lambda}{\delta c}\right) + \frac{\lambda c}{\phi}\frac{\delta\phi}{\delta c}\right]\frac{\delta c}{\delta x}$$

It has been shown that this generalized equation leads to all the other diffusion equations under certain specified conditions. A.

539.217

5667. The surface topography of diffusion couples. R. S. Barnes. *Defects in crystalline solids* [*Bristol*] 359–68. See Abstr. 5707 (1955).

For abstract, see Abstr. 11470 (1954).

539.217 : 539.185.9

5668. Diffusion coefficients in copper under fast neutron irradiation. W. M. Lomer. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. T/R*1540, 10 *pp.* (1954).

Numerical estimates of the effect of pile bombardment on the diffusion coefficients in copper are based on the vacancy diffusion model. There is only a rather narrow temperature range within which radiation-induced diffusion would be detectable even by indirect measurements. This range is centred round

450°K and extends not more than 100°K on either side of it. The results are very insensitive to the activation energy to move interstitial atoms, but depend markedly on the perfection of the crystal. No impurity effects are considered. It is concluded that experiments on the kinetics of build-up and decay of point defects would be far more informative than diffusion type experiments of a type which give results effectively integrated over a long period. A.

539.219

5669. Diffusion short circuits and their role in precipitation. D. TURNBULL. *Defects in crystalline solids* [*Bristol*] 203–11. See Abstr. 5707 (1955).

Recent experiments have indicated that dislocation channels and elements of incoherent grain boundaries are almost equally effective short circuits for the self-diffusion of silver. It is demonstrated that the rate of cell growth in cellular precipitation ("discontinuous" precipitation) of tin from lead and of silver from copper is controlled by the rate of diffusion of solute atoms in the cell boundary. Guinier–Preston zones grow at rates many orders of magnitude greater than predicted from the high temperature lattice diffusion constants. It is possible that dislocation channels facilitate the growth of these zones, but no quantitative theory has been developed. Rates of growth of general precipitate particles in some aluminium alloys are in satisfactory agreement with the predictions from the appropriate lattice diffusion constants. A.

539.23

5670. Growth of anodic Ta_2O_5 films during illumination with ultraviolet light. D. A. VERMILYEA. Letter in *J. appl. Phys.*, **26**, *No.* 4, 489 (*April*, 1955).

Experiments are reported which indicate that the increase in thickness of anodic film when illuminated with ultraviolet light during growth is due to the formation of a thick porous outer layer over a thin, dense, inner layer. The apparently greater increase in optical thickness than in thickness as deduced from capacitance measurements can be explained on this model. D. G. AVERY

539.234 : 535.323

5671. Note on the optical constants of copper. M. P. GIVENS. Letter in *J. opt. Soc. Amer.*, **45**, *No.* 3, 229–30 (*March*, 1955).

Measurements of the optical constants of evaporated layers of Cu are described, and the results compared with other work. The evaporations were carried out at pressures apparently $\sim 10^{-6}$ mm of Hg, or less, and it is suggested that these layers were oxide-free, as opposed to layers prepared at 10^{-5} mm pressure. This is supported by the absence of any abrupt change in the optical constants in the region 5 000–6 000 Å for the author's layers. D. G. AVERY

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.3 : 530.162

Statistico-mechanical theory of deformation, involving the activated state. *See Abstr.* 5233

539.3 : 534.222.2

Properties of elastic and plastic waves determined by pin contactors and crystals. *See Abstr.* 5279

539.32 : 536.71 : 539.11

Calculation of elastic coefficients of crystalline argon. *See Abstr.* 5548

539.32 : 548.0

5672. Elastic properties of single crystals and polycrystalline aggregates. S. BHAGAVANTAM. *Proc. Indian Acad. Sci. A*, **41**, *No.* 3, 72–90 (*March*, 1955).

A review of the measurement of the elastic constants of crystals and polycrystalline aggregates, using ultrasonic methods, made by the author and his collaborators over the past ten years. Results for various classes of crystals and some polycrystalline alkali halides are tabulated and the temperature dependence over the range 28–300°C is also given for iron pyrites, sodium chlorate, magnetite and polycrystalline sodium chloride. J. E. CAFFYN

539.32 : 548.0

5673. Measurement of the elastic constants of single crystal cobalt. H. J. MCSKIMIN. *J. appl. Phys.*, **26**, *No.* 4, 406–9 (*April*, 1955).

The five elastic constants of hexagonal cobalt have been determined using pulse modulated ultrasonic waves which are reflected back and forth within the crystal. Frequencies between 10 and 30 Mc/s were used. Values of the constants were derived from eleven measurements of wave velocities for longitudinal and shear modes in three crystals, using a phase comparison technique. At 25°C the constants (all in 10^{12} dynes/cm^2) are: $c_{11} = 3{\cdot}071 \pm 0{\cdot}5\%$, $c_{12} = 1{\cdot}650 \pm 0{\cdot}5\%$, $c_{13} = 1{\cdot}027 \pm 1{\cdot}5\%$, $c_{33} = 3{\cdot}581 \pm 0{\cdot}5\%$, $c_{44} = 0{\cdot}755 \pm 0{\cdot}5\%$. These are based on a density of 8·836. A.

539.37

5674. A theory of the tensile and compressive textures of face-centred cubic metals. J. F. W. BISHOP. *J. Mech. Phys. Solids*, **3**, *No.* 2, 130–42 (*Jan.*, 1955).

The theory assumes that each grain in the aggregate undergoes the macroscopic strain. The possible rotations of a representative set of grains due to a small increment of strain are computed. It is found that in each grain a range of rotations can occur. A hypothesis is advanced to account for the different textures observed under similar straining conditions by metals of the same lattice type. This is to the effect that the texture developed is determined by the relative hardening of active and latent glide systems. A further hypothesis enables the influence of specific types of hardening to be assessed. Diagrams compare observed and predicted textures. A.

539.37

5675. The departures from the statistical theory of rubber elasticity. A. G. THOMAS. *Trans Faraday Soc.*, **51**, *Pt* 4, 569–82 (*April*, 1955).

Observed departures at moderate strains in dry and swollen rubbers under various types of deformation are considered. It is shown that these departures are not explicable in terms of the finite extensibility effect, but may be correlated by means of a simple modification of the force extension relation for a single molecular chain. A.

539.374 : 541.64

5676. Extensions of the Rouse theory of viscoelastic properties to undiluted linear polymers. J. D. Ferry, R. F. Landel and M. L. Williams. *J. appl. Phys.*, **26**, *No.* 4, 359–62 (*April*, 1955).

With the effective segment mobility expressed in terms of steady-flow viscosity, the theory is applied to polymers of rather low molecular weight essentially without further change. In high molecular-weight polymers, it is assumed that for modes of motion with relaxation times above a critical value the effective segment mobility drops abruptly, in accordance with the effect of entanglement coupling on steady-flow viscosity as described by Bueche. Properties in both the transition region between glass-like and rubber-like consistency and the rubber-like or plateau region are predicted semiquantitatively with no arbitrary parameters. In an alternative application to the transition region, the average effective friction coefficient per monomer unit can be calculated for both linear and lightly cross-linked systems. A.

539.4.016.2 : 548.7

5677. Stored energy and lattice defects in cold-worked metals. W. Boas. *Defects in crystalline solids* [*Bristol*] 212–21. See Abstr. 5707 (1955).

Measurements have been made of the changes in internal energy, electrical resistivity, density and hardness which occur during the annealing of copper and nickel deformed at room temperature. The results indicate that almost all the energy stored in copper is due to dislocations, but that vacancies make a significant contribution to that stored in nickel. A.

539.42 : 548 : 536.421.1

Theory of melting and yield strengths. *See Abstr.* 5360

539.434

5678. Some fundamental experiments on high temperature creep. J. E. Dorn. *J. Mech. Phys. Solids*, **3**, *No.* 2, 85–116 (*Jan.*, 1955).

At high temperatures, the creep strain, ε, appears to be a function of a temperature (T), compensated time (t), namely $te^{-\Delta H/RT}$, and the stress. X-ray analyses and plastic properties reveal that the same structures are developed at the same values of $te^{-\Delta H/RT}$ following creep at the same stress. Thus $\varepsilon = f(te^{-\Delta H/RT})$, for the same stress. When the creep rate, $\dot{\varepsilon}$, is evaluated as a function of stress, σ, for the same structure $\dot{\varepsilon} = Se^{-\Delta H/RT}\phi(\sigma)$ where S depends on the structure and

$$S\phi(\sigma) = \begin{cases} S' e^{B\sigma} & B\sigma \geqslant \sim 1{\cdot}4 \\ S''\sigma^{n} & B\sigma \leqslant \sim 1{\cdot}4 \end{cases}$$

Although B and n appear to be insensitive to structural changes attending creep of annealed alloys, they decrease with increasing solute additions and cold working. Transients attending loading and unloading and the coincidence of the activation energy for creep, ΔH, with that for self-diffusion suggest that high temperature creep might be ascribed to a dislocation climb process. A.

539.434

5679. The creep of aluminium under cyclotron irradiation. M. R. Jeppson, R. L. Mather, A. Andrew and H. P. Yockey. *J. appl. Phys.*, **26**, *No.* 4, 365–7 (*April*, 1955).

The effect of cyclotron irradiation by 38 MeV α-particles on the steady-creep rate ($\sim 10^{-6}$ per sec) of aluminium has been measured at beam densities up to $1{\cdot}2 \times 10^{13}$ particles per cm^2 per sec. The data, which were taken on a 0·016 in. thick aluminium specimen for a stress range of 600 to 2 500 lb/in^2 and over a temperature range of 160 to 330°c, showed a slight decrease in rate (up to 19%) during irradiation. Since the effect is small, apparently independent of beam density, and is comparable to the usual deviations in the absence of radiation, it can be considered a null result. A.

539.434

5680. Recovery and recrystallization in metals examined in terms of the restoration of the transient creep properties. A. J. Kennedy. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 5, 257–76 (*May*, 1955).

Pure lead wires extended by creep under identical conditions have been subjected to a period of anneal, during which the stress was removed, and then retested under the original creep conditions. The effect of the temperature, the time of the anneal and the grain size on the subsequent creep properties have been examined. As far as the grain size is concerned, there appears to be very little effect until the grain diameter becomes commensurate with the specimen diameter, when the amount of recovery softening, under any particular conditions, increases. The general features of interrupted creep observed previously by the author in leads which did not recrystallize are again exhibited, in particular, the creep results can be fitted by assuming some fraction N of the material to have had its original creep properties fully restored. This fraction is now made up of both recovered, n, and recrystallized, X, material. The time function of the recovery process is the same as that observed in the non-recrystallizing leads, and it is thus possible to compute the values of n and X in any particular case. A theory of recrystallization is developed based on the concept that nuclei are formed by the recovery process; this is shown to satisfy the observations and provides an activation energy for the growth of new material of 31 000 cal mole^{-1}. The activation energy for recovery is found to be 19 800 cal mole^{-1} and that for creep 18 400 cal mole^{-1}. Some consequences of this approach are reviewed in the light of previous work. A.

539.501

5681. The rheology of Portland cement pastes. G. H. Tattersall. *Brit. J. appl. Phys.*, **6**, *No.* 5, 165–7 (*May*, 1955).

Experiments with a rotation viscometer on the structural breakdown of Portland cement/water pastes are described. Hysteresis curves are shown and an empirical equation $T = T_E + (T_0 - T_E)\exp(-Bt)$ for the decay of torque T with time t, at constant rate of shear, is given. The equation is also derived theoretically by assuming that the "excess torque" is proportional to the number of linkages existing, and it is shown that the predicted dependence of B on the rate of shear is approximately fulfilled by the experimental results. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.1 : 535.343 : 537.226 : 539.132

5682. An advanced treatise on physical chemistry. Vol. 5: Molecular spectra and structure, dielectrics and dipole moments. J. R. PARTINGTON. *London: Longmans, Green and Co.* (1954) x + 565 *pp.*

Review in *Nature* [*London*] **175,** 741–2 (*April* 30, 1955).

541.124

5683. Methyl and phenyl affinities of aromatic compounds. D. H. HEY AND G. H. WILLIAMS. Letter in *J. chem. Phys.*, **23,** *No.* 4, 757 (*April*, 1955).

Relative phenyl affinities of different aromatic compounds have been measured by analogous methods to those used for relative methyl affinities [Abstr. 582 (1955)]; the two quantities are nearly equal for naphthalene, and for diphenyl, and similar for pyridine. The ratios of different isomers formed in the phenylation were measured for these compounds, and for various benzene derivatives; the relative reactivities of different positions were thereby obtained, and agreed well with MO calculations.

J. HAWGOOD

541.126

5684. On the structure of a detonation front. W. R. GILKERSON AND N. DAVIDSON. *J. chem. Phys.*, **23,** *No.* 4, 687–92 (*April*, 1955).

An effort was made to observe the structure of the reaction zone for a detonation in a gas. Detonations in a 50% H_2 : 50% O_2 mixture at 0·035 atm. pressure containing 1% I_2 were initiated by shock waves in a shock tube. Because of ignition delays and the short length of tube available the detonations did not settle down to a steady state and were of unexpectedly high velocity. The iodine served as a calorimetric indicator for the shock front. The light output of the detonation is a step function of time with a front coincident with the shock front within 2–3 μsec. The experiment indicates that the reaction zone is less than 10^4 collisions thick. A crude theoretical estimate of the reaction zone thickness of 1 000–4 000 collisions is made. Possible chain initiating steps are also considered. A.

541.127/.128

5685. Acid catalysis in the thermal decomposition of ammonium nitrate. B. J. WOOD AND H. WISE. *J. chem. Phys.*, **23,** *No.* 4, 693–6 (*April*, 1955).

Experimental measurements of the kinetics of thermal decomposition of ammonium nitrate have been made in the temperature range from 443 to 553°K. The results indicate that the degradation of ammonium nitrate is an autocatalytic liquid-phase reaction, the rate of which is proportional to the product of the mass of salt and the concentration of acid. The activation energy for this process is found to be 31·4 kcal. Adjustment of the concentration of acid present offers an effective means for the control of the rate of thermal degradation of ammonium nitrate. A.

541.127

5686. On N. S. Akulov's theory of "autogenesis." V. I. SKOBELKIN. *Zh. éksper. teor. Fiz.*, **27,** *No.* 4(10) 501–9 (1954) In Russian.

Discussion paper. A criticism of the theory of the kinetics of chemical reactions, published in Akulov's *The fundamentals of chemical dynamics* [MGU, Moscow, 1940] and *The theory of chain processes* [Gittl, M.–L., 1951], which, in place of the law of mass action, proposes an expression for the rate of a reaction depending explicitly on time and implying a finite discontinuity at some "induction time." According to Skobelkin these phenomena of "autogenesis" are entirely the results of mathematical errors.

W. J. SWIATECKI

541.127

5687. On a new method of drawing the potential energy surface. S. SATO. Letter in *J. chem. Phys.*, **23,** *No.* 3, 592–3 (*March*, 1955).

A new method for the interpretation of reactions is suggested and applied to a system of three H atoms. A function for the potential energy of two atoms in antibonding state is proposed. An equation for the potential energy of the system slightly different from that developed by London is found, which contains a term corresponding to the square of the overlap integral. By this method it is also found that the transition state contains three atoms in one straight line. The potential energy surface contains only one saddle point and no basin. This agrees with the results of non-empirical calculations. The value of the saddle point corresponds to the experimental value of the activation energy. A value for the Coulomb fraction $>0·20$ is indicated. The method can also be applied if $r < 1·0$ a.u. A. J. TAYLOR

541.127.1 : 539.232

5688. Rate of formation of film on metals and alloys. G. P. CHATTERJEE. *J. appl. Phys.*, **26,** *No.* 4, 363–5 (*April*, 1955).

The rate of atmospheric corrosion of Cu–Zn and Cu–Mg alloys is retarded by Al or Mn, and the law of the growth of film in the case of Cu–Zn alloys changes over from the parabolic to the logarithmic law on the addition of Al or Mn. For Cu–Mg alloys under a given set of conditions the law of the growth of film is governed by $x^{\frac{1}{2}} = k_1 \log t + k_2$, where x is the film thickness, t is time and k_1 and k_2 are constants. It has been indicated that some experimental data on the corrosion of metals and alloys may be quantitatively represented if two or more functions, representing different mechanisms of the growth of film, are taken into consideration simultaneously. A.

541.128

5689. The reaction between nitric and nitrous oxide. F. KAUFMAN AND J. R. KELSO. Letter in *J. chem. Phys.*, **23,** *No.* 3, 602–3 (*March*, 1955).

The catalytic effect of NO in the decomposition of N_2O was reinvestigated between temperatures of 924–1 028°K, rate data being obtained by a spectrophotometric analysis of the oxygen formed. The reaction is first-order in NO and in N_2O. The

activation energy is 50 kcal. The importance of the NO-catalysed reaction decreases with increasing temperature. A. J. TAYLOR

541.128

5690. Activation energy and entropy for adsorption. T. KWAN. Note in *J. phys. Chem.*, **59**, *No.* 3, 285–6 (*March*, 1955).

The relationship between the activation energy and the frequency factor in a chemical reaction occurring over a series of catalysts is discussed by reference to the adsorption of nitrogen on a promoted iron catalyst. It is shown that the energy and the entropy of activation for the adsorption are "compensatory," and that the differential entropy of adsorption (for a suitable standard state) and the isosteric heat of adsorption are likewise "compensatory." S. J. GREGG

ELECTROCHEMISTRY 541.13

541.133

5691. Mobility of protons in ice. A. SPERNOL. *Z. Elektrochem.*, **59**, *No.* 1, 31–2 (1955) In German.

The resistance of 0·01–0·2 M solutions of HCl, NaOH and KCl in polycrystalline ice were measured by means of an a.c. bridge in temperature range from 0 to −50°C. The molal conductivity of KCl solutions was lower by ∼2 orders of magnitude than those of HCl and NaOH solutions. A very steep decrease of conductivity takes place when the temperature falls from 0 to −15°, whereas further decrease, below −15°c, obeys an exponential law. The fundamental difference between the conductivity of KCl solutions on the one hand, and that of HCl and NaOH solutions on the other seems to point to the existence of a special mechanism of proton migration. F. LACHMAN

541.135

5692. A pressure electrolyzer unit. J. FLINTA. *Appl. sci. Res. B*, **4**, *No.* 4, 249–54 (1955).

An electrolytic cell has been built for filling pressure cylinders with deuterium at high pressure. The bottles are filled directly from the cell using the electrolytic liberating pressure of D_2 and O_2. The levels of the electrolyte are held constant by means of an electromagnetically operated leak, controlled by the current through the electrolytic cell. A.

541.135.5

5693. Potential at zero charge for reversible and ideal polarized electrodes. P. RÜETSCHI AND P. DELAHAY. *J. chem. Phys.*, **23**, *No.* 4, 697–9 (*April*, 1955).

The potential at zero charge for an ideal polarized electrode, as measured with respect to some reference electrode, varies linearly with the work function of the metal, while this potential for a reversible electrode is independent of the nature of the electrode. This observation is verified experimentally for Ag, Cd, Cu, Ga, Hg, Ni, Pb, Pt and Tl in the case of ideal polarized electrodes and for Ag, Au, Bi, Cu, Hg and Pt for reversible electrodes. It is shown that the difference between the Volta potentials from electrode to solution for an ideal polarized electrode at zero charge is approximately −0·33 volt, and that the difference between the Galvani potentials is equal to the surface potential of the electrode. The difference of Volta potentials for a reversible electrode at zero charge varies linearly with the electronic work function of the metal. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.15

5694. Nitrogen fixation in a nuclear reactor. W. PRIMAK AND L. H. FUCHS. *Nucleonics*, **13**, *No.* 3, 38–41 (*March*, 1955).

Samples of nickel wire in ampoules containing moist and dry atmospheres of oxygen, nitrogen and air, were irradiated in the central thimble of the Argonne CP–3 reactor. No reactions were observed to occur in the dry gases, but a black product was formed in moist oxygen and in moist air a green soluble salt, identified as $Ni(NO_3)_2.3H_2O$, was produced. This results from the fixation of nitrogen in the ionized atmosphere and subsequent reaction with the metal. It is estimated that about one N atom is fixed for each ion pair formed in the gas by the neutrons and γ-radiation. L. R. SHEPHERD

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.183

5695. Autophobic liquids and the properties of their adsorbed films. E. F. HARE AND W. A. ZISMAN. *J. phys. Chem.*, **59**, *No.* 4, 335–40 (*April*, 1955).

A class of polar liquids has been found having the remarkable property of being unable to spread on their own adsorbed films. Many branched as well as unbranched polar compounds exhibit these properties on high energy surfaces as diverse as platinum, α-alumina and fused silica. A rectilinear relation exists between the cosine of the contact angle of each liquid and the surface tension. It is demonstrated that the "autophobic" property of such liquids is caused by the adsorption of an oriented monolayer of the liquid. When the resulting low energy surface has a critical surface tension below the surface tension of the liquid, non-spreading or "autophobicity" results. Studies of the effect of varying the baking temperature of α-alumina and silica on the contact angles of autophobic liquids revealed that considerable surface dehydration of α-alumina and vitreous silica surfaces takes place at 200°. The effect of such dehydration was to decrease the contact angles in every instance, the effect being greatest on α-alumina. It is concluded that the acids and alcohols studied were able to adsorb on silica and α-alumina through hydrogen bonding to the adsorbed water layer. A.

541.183 : 536.48

5696. Microbalance assembly for adsorption studies at low temperatures. R. BOWERS AND E. A. LONG. *Rev. sci. Instrum.*, **26**, *No.* 4, 337–41 (*April*, 1955).

An assembly is described, suitable for the measurement of adsorption isotherms at liquid helium temperatures by the gravimetric method. The design leaves the balance readily accessible and overcomes the two principal difficulties which are spurious mechanical disturbances and buoyancy effects. A.

541.183.5 : 531.752

Measurement of sorption on polystyrene with torsion balance. *See Abstr.* 5243

CHEMICAL ANALYSIS 543/545

544.64

5697. X-ray emission spectroscopy with electron excitation covering elements $_4$Be–$_{92}$U. G. L. Macdonald and M. G. Harwood. *Brit. J. appl. Phys.*, **6**, *No.* 5, 168–72 (*May*, 1955).

A plane glass optical diffraction grating has been used to disperse characteristic X-rays, of wavelengths 5–200 Å, produced by electron bombardment of materials. Advantages of an electron as opposed to an X-ray source for the analytical determination of the elements by X-ray spectroscopy are discussed. It is shown that almost any element throughout the periodic system can be detected with one photographic exposure, using *K*, *L*, *M* and *N* radiations. Light and heavy elements are recorded with equal facility. X-ray spectroscopy and electron diffraction have been combined to produce simultaneous elementary and compound analysis. The particular advantages of the method for the identification of surface films are noted. A.

545.7 : 539.172.4

5698. Improved methods for the routine radiochemical analysis of fission product mixtures. I. The recognition of radiochemical purity using aluminium absorption curves. G. Phillips and E. N. Jenkins. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. C/R* 1534, 8 *pp.* (1954).

It has been shown that the Automatic Absorber/Sample Changer Type 1112A may be used to obtain reproducible aluminium absorption curves under fixed conditions of source weight, mounting and geometry. The reproducibility is maintained with successive sources, Geiger tubes and Automatic Absorber Changers. A library of standard absorption curves is presented, for many of the common fission products, mounted on 30 mg of carrier precipitate and spread over a deep aluminium tray (A.E.R.E. Catalogue No. 4–3/1068). A.

CRYSTALLOGRAPHY 548

548.33

5699. Polymorphism in one dimension. C. J. Schneer. *Acta cryst.*, **8**, *Pt* 5, 279–85 (*May*, 1955).

An admissible set of structures is defined to contain all stackings of rigid hexagonal nets at constant vertical interval with the nodes of each net centred on the nodes of the net below. The immediate environment of each net is either cubic or hexagonal. If V is the difference in potential energy between layers in the two environments, the ratio of the number of nets h to the number c is given by $n_h/n_c = \exp[-V/kT]$ (the Boltzmann factor). Setting this equal to $(1-D)/D$, a distribution function D is defined equal to the probability that a given layer is in the state c. By discarding the one-dimensional approximation, V becomes proportional to D and the polymorphism is co-operational with a critical temperature. By assuming a difference in interaction energy between two layers depending on whether the layers are in the same or in different states, the long-period polymorphs are shown to represent potential minima. The 15 observed polymorphs of silicon carbide are characterized by maximum numbers of interaction contacts between layers in unlike states. The phase transformation proceeds over a temperature range by infinitesimal steps so that density and probability distribution vary continuously across a critical temperature while derivatives of these are discontinuous. An anomalous heat capacity replaces latent heat. Intermediate phases appear at simple proportions of layer types, unaccompanied by discontinuities. A.

548.33 : 536.424.1

5700. Cubic to orthorhombic diffusionless phase change—experimental and theoretical studies of AuCd. D. S. Lieberman, M. S. Wechsler and T. A. Read. *J. appl. Phys.*, **26**, *No.* 4, 473–84 (*April*, 1954).

A theoretical analysis of the cubic to orthorhombic transformation is presented which predicts for a partly transformed crystal, the interface plane, orientation relationships and macroscopic distortions from a knowledge only of the lattice parameters of the initial and final phases. Arguments are advanced to show that in order to minimize the strain energy associated with the transformation, the interface plane must be one of zero average distortion. This leads directly to considerations of an inhomogeneous product phase. Experimental studies on an AuCd alloy are described and the observed crystallographic features of the transformation compared with values calculated using the theory. The agreement between calculated and observed results for this alloy system as well as others is strong evidence for the theory of diffusionless phase transformations presented. A.

548.5

5701. Growing of perovskite-type crystals. H. F. Kay and J. L. Miles. *Rep. Brit. Elect. Res. Assoc. Rep. L/T*303, 11 *pp.* (1954).

Brief descriptions of methods for growing some titanates, niobates, tantalates and gallates from the melt or solution. Crystals more than 1 mm long were rarely obtained except in the case of $BaTiO_3$. Hydrothermal methods have so far not proved successful. J. FRANKS

548.5

5702. The topography of solid-liquid interfaces of metal crystals growing from the melt. C. Elbaum and B. Chalmers. *Canad. J. Phys.*, **33**, *No.* 5, 196–208 (*May*, 1955).

An improved technique of separating the liquid portion of the metal from the adjacent crystal has been developed. Microscopic examination of the interfaces prepared by this method has revealed a new surface structure. It has been found that the presence or

absence of the structure depends on the crystallographic orientation of the specimen. The structures have been observed in all of the metals investigated in the present work, namely lead, tin and zinc. A detailed study of the structure has been made in the case of lead. It was observed that, when the angle between the macroscopic plane of the interface and either the (111) or the (001) plane was less than a certain critical value, the interface consisted of steps or terraces approximately 0·001 mm high. A mechanism for the formation of those steps is proposed. A.

548.5

5703. Growth of monocrystals of germanium from an undercooled melt. E. Billig. *Proc. Roy. Soc. A*, **229**, 346–63 (*May* 10, 1955).

Dissipation of latent heat being the main rate-controlling factor in crystal growth from the melt, a novel technique has been developed for the rapid growth of monocrystals of germanium and other materials with the diamond or zincblende structure. By dipping a properly orientated seed crystal into an under-cooled melt and withdrawing it at the same rate as it grows, monocrystals of indefinite length can be obtained with various shapes which are under reasonable control; in particular, crystals can be grown in the form of thin lamellae, demonstrating in a striking fashion that even in an isotropic medium of cubic symmetry, crystal growth can take place by the deposition of individual layers orientated along the close-packed {111} planes. Further evidence for growth by layer formation is deduced from etch experiments. The surfaces of some of these crystals have a high degree of perfection. Crystal surfaces as grown, and also after having been etched, have been examined in detail under the optical, phase-contrast and electron microscopes, as well as with a fine-focus X-ray beam; certain growth features are discussed and a possible mechanism is suggested for dendritic growth. A.

548.5 : 548.7

5704. Crystal growth and lattice defects. W. Dekeyser. *Defects in crystalline solids* [*Bristol*] 134–42. See Abstr. 5707 (1955).

A brief review of work done at the Crystallographic Laboratory of the University of Ghent. A.

548.517 : 541.64

5705. Crystallization kinetics in high polymers. II. Polymer-diluent mixtures. L. Mandelkern. *J. appl. Phys.*, **26**, *No.* 4, 443–51 (*April*, 1955).

For Pt I, see Abstr. 8765 (1954). The rates of crystallization of two polymer-diluent mixtures, poly-(ethylene oxide)-diphenyl ether and poly-(decamethylene adipate)-dimethyl formamide were studied at various temperatures ranging from 6 to 15° below the melting points of the mixtures. The various mixtures investigated encompassed a wide range of compositions; the volume fraction of the diluent v_1 ranged from about 0·10 to 0·70. The crystallization behaviour observed was strikingly similar to that previously reported for bulk polymers in Pt I. The results are interpreted by making the necessary modifications to the treatment previously employed wherein steady-state nucleation and growth were assumed to occur simultaneously throughout the process. Agreement obtained between theory and experiment is similar to the corresponding results for the bulk polymer. A.

548.574 : 537.226.2

5706. Etch patterns and ferroelectric domains in $BaTiO_3$ single crystals. J. A. Hooton and W. J. Merz. *Phys. Rev.*, **98**, *No.* 2, 409–13 (*April* 15, 1955).

It has been found that ferroelectric $BaTiO_3$ single crystals show a differential etch rate when etched in hydrochloric acid. The positive end of the electric polarization etches much faster than the negative one. Thus this phenomenon affords a valuable new tool for the investigation of the ferroelectric domains in $BaTiO_3$. Some interesting pictures of domain arrangements are shown and discussed. The results obtained demonstrate the extremely strong electric dipole-dipole coupling in the forward direction and the weak coupling in the directions perpendicular to it. This electrostatic interaction governs the domain patterns in ferroelectric $BaTiO_3$ crystals. A.

ATOMIC AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

5707. Defects in crystalline solids. *London: The Physical Society* (1955) 429 *pp.* + 25 *plates.*

Report of a conference held at the H. H. Wills Physical Laboratory, University of Bristol, July, 1954, in co-operation with the International Union of Physics, the Institute of Physics and the Physical Society. Forty-seven papers are printed and these are abstracted individually.

548.7

5708. Nuclear magnetic resonance in imperfect crystals. N. Bloembergen. *Defects in crystalline solids* [*Bristol*] 1–32. See Abstr. 5707 (1955).

A systematic survey is made how various kinds of imperfections in a crystalline lattice will affect the position, breadth, shape and relaxation time of the nuclear magnetic resonance. In accordance with Seitz's classification the following imperfections are considered: (i) dislocations, (ii) vacant lattice sites and interstitial atoms, (iii) foreign atoms in either interstitial or substitutional position, (iv) electrons and holes, (v) photons, (vi) excitons. Their interaction with the magnetic dipole moment and the electric quadrupole moment of the nuclei at the normal lattice sites is discussed and the available experimental information is reviewed. A.

548.7

5709. Some observations of the paramagnetic resonance absorption, conductivity and optical absorption of single crystals of sodium chloride containing manganese. E. E. Schneider and J. E. Caffyn. *Defects in crystalline solids* [*Bristol*] 74–80. See Abstr. 5707 (1955).

Sodium chloride crystals containing manganese have been quenched to room temperature and the paramagnetic resonance absorption of the manganese has been examined. In addition the conductivity and optical absorption of the quenched and slowly cooled

specimens has been studied, together with the coloration of the crystals with γ-radiation. Alternative models which describe the distribution of the manganese in the quenched and slowly cooled state are discussed. A.

548.7

5710. Magnetic resonance in irradiated diamond and quartz. J. H. E. Griffiths, J. Owen and I. M. Ward. *Defects in crystalline solids* [*Bristol*] 81–7. See Abstr. 5707 (1955).

In diamond, neutron irradiation produces magnetic centres (and coloration) which give rise to a microwave spectrum. It is found that there are two main types of resonance absorption line: (*a*) a single isotropic line with *g*-value close to 2, the intensity of which can be greatly reduced by heating the diamond to about 1 000°c; (*b*) many less intense anisotropic lines, whose intensity is not much affected by heat treatment, and which appear to arise from centres with electronic spin $S = 1$. The experimental results are tentatively compared with Pryce's theory of the magnetic centres arising from radiation damage in the diamond lattice, which involves interstitial carbon atoms, carbon vacancies and possible C_2 molecules. In quartz, X-irradiation produces magnetic centres (and a smoky coloration) which are removed by heating to 300°c. The microwave spectra from these centres are described, and it is suggested that they are associated with impurity Al atoms which have replaced Si atoms in the quartz lattice. The electronic spin is $S = \frac{1}{2}$, the *g*-values anisotropic and fairly close to 2, and there is a complicated hyperfine structure showing effects both from the magnetic moment and from the quadrupole moment of the Al nucleus. A.

548.7

5711. Paramagnetic resonance in irradiated diamond and quartz: interpretation. M. C. M. O'Brien and M. H. L. Pryce. *Defects in crystalline solids* [*Bristol*] 88–91. See Abstr. 5707 (1955). See preceding abstract.

548.7 : 535.345

5712. The effect of dislocations on the optical absorption edge in non-metals. R. M. Blakney and D. L. Dexter. *Defects of crystalline solids* [*Bristol*] 108–20. See Abstr. 5707 (1955).

Calculations are presented as to the extent to which dislocations may be expected to influence the fundamental electronic absorption spectra of insulators and semiconductors. For several reasonable types of band structure an absorption coefficient of the order 10^2–10^3 per cm may be expected for several hundred ångströms on the long wavelength side of the absorption edge in a heavily cold-worked crystal. A.

548.7

5713. Types of dislocation source. B. A. Bilby. *Defects in crystalline solids* [*Bristol*] 124–33. See Abstr. 5707 (1955).

Dislocations may be created under low stresses by the operation of dislocation sources, or spontaneously if stress concentrations of sufficient magnitude occur. The multiplication mechanism known as the Frank–Read source (here called the "plane source") is only one of the ways in which dislocations may be generated at a dislocation node. Unless the Burgers vector of the pole dislocation (assumed to lie on both sides of the sweeping dislocation) lies in the sweeping plane a different kind of source, the "cone source," producing homogeneous slip, is formed. An estimate is made of the relative number of plane and cone sources in a dislocation network in the face-centred cubic lattice. It is concluded that the numbers of single sources of these two types are of the same order of magnitude; any differences are increased when double sources are considered, and cone double sources are probably rather more rare. Some consequences of the existence of cone sources are discussed qualitatively. The spontaneous creation of dislocations may occur during the deformation accompanying indentation, since large stress concentrations are then present. Dislocations formed near an indentation often arrange themselves in two-dimensional arrays round the indenting point, and it is convenient to treat these arrays as entities. They are surface dislocations, in contrast to the normal line dislocations and are characterized not by a Burgers vector, but by a dislocation tensor. A surface dislocation in the general case separates two volumes of material where the crystal lattices are different, and the fundamental relation connecting this tensor with the nature of the lattices and the orientation of the surface dislocation is derived. The theory of surface nodes (which occur when surface dislocations meet along a line) is also discussed. Two simple examples of surface nodes are given. A.

548.7

5714. Dislocations in face-centred cubic lattices. N. Thompson. *Defects in crystalline solids* [*Bristol*] 153–8. See Abstr. 5707 (1955).

Consideration is given to the limitations imposed by the geometry of the crystal lattice on the nature and configuration of dislocations in a face-centred cubic lattice. Particular reference is made to the form and properties of "jogs" in dislocation lines. A.

548.7

5715. Hexagonal networks of dislocations. F. C. Frank. *Defects in crystalline solids* [*Bristol*] 159–68. See Abstr. 5707 (1955).

The nature of the dislocations forming hexagonal networks as observed by Hedges and Mitchell [Abstr. 6354 (1953)] is discussed. It is shown that there is only a restricted range of possibilities and the simplest and presumably commonest type corresponds to disorientations by rotation about a (111) axis. A.

548.7

5716. An experimental study of dislocations in aluminium–copper alloys by means of precipitation. H. Wilsdorf and D. Kuhlmann-Wilsdorf. *Defects in crystalline solids* [*Bristol*] 175–86. See Abstr. 5707 (1955).

Precipitation in aluminium–copper alloys, containing 1·2, 2·2 and 4·8% copper, was investigated with the principal object of studying preferred precipitation in dislocations. Since dislocations exist in slip lines, elementary structures and sub-grain boundaries, and also probably in low angle grain boundaries, all these phenomena were examined, and conclusions about the dislocations in them were drawn. Many examples of a special structure, consisting of rows of densely spaced,

similarly oriented precipitates were discovered and examined. They are thought to represent precipitates nucleated in individual dislocations. A.

548.7 : 539.217

5717. Structure and anisotropy of diffusion in grain boundaries. R. SMOLUCHOWSKI. *Defects in crystalline solids* [*Bristol*] 197–202. See Abstr. 5707 (1955).

(*a*) While the structure and various properties of grain boundaries at small angles of disorientation are well explained on the basis of the dislocation model and at very large angles of disorientation the model of an isotopic slab of generally distorted material is applicable, at intermediate angles the structure is not so well understood although the dependence of grain boundary diffusion and of its activation energy upon the angle of disorientation can be interpreted in terms of elongated, rod-like, regions of distorted crystalline structure. In order to throw additional light on this problem, the diffusion of silver in a grain boundary of copper as a function of the angle between the direction of diffusion and the common cubic direction of the grains was studied for various angles of disorientation of the grains. The results indicate a definite anisotropy, the highest rate of diffusion being in the common cubic direction. Highest anisotropy occurs at the lowest angles at which any grain boundary diffusion is observed and it decreases to zero at the highest angle of disorientation. (*b*) The presence of minima of grain boundary energy at particular angles of disorientation at which certain atoms are common to both grains suggests that similar minima can occur in the grain boundary diffusion. From a study of self-diffusion of iron along its grain boundaries it appears that although the position of minima of grain boundary penetration agrees with the minima of the energy the relative importance (i.e. depth) of these cusps is different. It is proposed that the penetration at a cusp orientation depends upon the density of atoms of misfit than upon the spacing between atoms common to both grains. A quantitative comparison with experiment seems to support this point of view. (*c*) A new approach to the estimate of grain boundary energies based on the use of a Morse potential seems to give promising results for intermediate and high-angle boundaries. A.

548.7

5718. Recent experiments at Harwell on irradiation effects in crystalline solids. R. A. DUGDALE. *Defects in crystalline solids* [*Bristol*] 246–51. See Abstr. 5707 (1955).

A brief account is given of bombardment effects in boron nitride, some pure metals and the alloy Cu_3Au. A.

548.7

5719. Behaviour of defects in alkali halides produced by high-energy protons and gamma rays. R. SMOLUCHOWSKI. *Defects in crystalline solids* [*Bristol*] 252–5. See Abstr. 5707 (1955).

The formation of lattice defects in ionic crystals by means of high-energy (around 400 MeV) protons and γ-rays permits a convenient study of their behaviour as a function of concentration, temperature, etc. The crystal density as measured by the suspension method shows a decrease up to 5×10^{-4} for a total proton irradiation flux of the order of 10^{17}. The presence and concentration of negative ion vacancies associated with this change of density is confirmed by a subsequent deep coloration throughout the volume of the crystals by a standardized X-ray irradiation which, on normal crystals, produces only a thin surface coloration. The same effect is found on quenched crystals. Clustering is considered responsible for the rapid increase of ionic resistivity of the irradiated crystal which reaches values over 200 times higher than normal at about 200°C. This occurs with an activation energy of 1·5 eV. The *V*-bands, though present, seem to be too weak to affect appreciably the ionic conductivity. A gradual return to normal resistivity at higher temperatures is presumably connected with dissociation of clusters and annealing out of the defects. The initial increase of resistivity at about 100°C produced by a flux of 10^{13} decreases with increasing total flux and changes to a drop of resistivity at about 10^{17}. Formation of "stars" and out-of-phase regions may play a significant rôle in irradiation effects by high-energy protons. A.

548.7

5720. Colour centres induced in Al_2O_3 by reactor and gamma-ray irradiation. P. W. LEVY AND G. J. DIENES. *Defects in crystalline solids* [*Bristol*] 256–60. See Abstr. 5707 (1955).

The absorption bands induced in α-Al_2O_3 by γ- and reactor-irradiation have been studied. The slight coloration due to γ-rays saturates. Bands specific to reactor irradiation have been found and their growth studied. A.

548.7

5721. Concentration and association of lattice defects in NaCl. Y. HAVEN. *Defects in crystalline solids* [*Bristol*] 261–72. See Abstr. 5707 (1955).

In NaCl containing small amounts of divalent impurities like Ca^{2+}, Cd^{2+}, Mn^{2+}, etc. the (−) Na-vacancies are captured by the (+) divalent ions. The concentration of associates (Ca^{2+}–Na vacancy) can be deduced rather accurately from dielectric measurements. The concentration of free ions can be deduced much less accurately from conductivity measurements. It appears that not only the equilibrium Ca^{2+} + Na-vacancy $\rightleftharpoons$ (Ca^{2+}–Na vacancy) plays a rôle, but also the associates consisting of more individuals. The different behaviour of Cd^{2+} and Ca^{2+} is largely determined by the segregation of mixed crystals for Cd^{2+}, rather than by the pair association. At room temperature the vacancies have still a relatively large mobility. The mobility of the associated vacancies seems to be higher than of free vacancies. The Cl^--vacancies seem to have a mobility that is about a factor 6 smaller than Na-vacancies. Isotypic mixed crystals like NaCl–NaBr do not exhibit an excessive concentration of lattice defects. A.

548.7 : 537.226.33

5722. Dielectric relaxation in impure polar crystals. A. B. LIDIARD. *Defects in crystalline solids* [*Bristol*] 283–96. See Abstr. 5707 (1955).

The controlled introduction of vacancies into alkali and silver halide crystals by the solution of small quantities of divalent cations (e.g. by addition of $CdBr_2$ to AgBr) has formed the basis of a number of investigations into the nature of the imperfections existing in these crystals. The currently accepted

model of these "anomalous" solutions is as follows: The divalent ions enter the cation sublattice substitutionally; the condition of electroneutrality then requires the simultaneous creation of an equal number of vacancies. Owing to the unbalanced positive charge on the impurity ion and the effective negative charge of the vacancy, the system forms a sort of electrolyte solution. Some of the vacancies become attached to impurity ions at the nearest neighbour position to form "complexes" which are dipolar. The behaviour of this model under the action of an alternating electric field is analysed in this paper. It has been appreciated for some time that the dipolar complexes will lead to dielectric relaxation effects described by the familiar Debye equations. However, there has been confusion over the number of distinct relaxation times which characterize this model. Although the complex can change its orientation both by a direct exchange of places between the impurity ion and the vacancy, and also by jumps of the vacancy around the impurity as centre, it is shown how these two processes combine to give only a single relaxation time. Isothermals of loss, $\tan\delta$, plotted against the logarithm of the frequency ω determined experimentally by Haven nevertheless indicate the existence of more than one relaxation time, being about 1·5 times wider than one would expect from the Debye equations. The possibility that this broadening can be explained by taking account of excited complexes (i.e. those impurity–vacancy pairs of greater separation than nearest neighbours) is explored, but owing to our uncertain knowledge of a number of the relevant parameters it is difficult to reach a definite conclusion. In particular, when we consider only nearest neighbour and next nearest neighbour complexes, we find substantial displacements of the position and height of the loss maximum but scarcely any alteration in the shape of the curves, i.e. the reduced curves $[(\tan\delta/\tan\delta_{max}), \log(\omega/\omega_{max})]$ are identical to within a few per cent. To obtain any appreciable broadening it seems necessary to include also the third nearest neighbour pairs, but the resulting theory then contains five unknown parameters of which only two (the relative populations) can be estimated easily. A.

548.7 : 537.312.5

5723. Photoconductance of *F*-centres and their aggregates. G. W. Neilson and A. B. Scott. *Defects in crystalline solids* [*Bristol*] 297–303. See Abstr. 5707 (1955).

Experiments on the photoconductance of *F*-centres in additively coloured KCl and KBr show that there is a marked decrease in the photoconductance of freshly prepared crystals after illumination in the *F*-band or upon ageing in the dark, even though the concentration of *F*-centres is only slightly decreased. The theory of this effect is discussed. Photoconductance measurements are a useful supplement of absorption measurements in studying the products of thermal and optical coagulation of *F*-centres. For example, the spectral distribution of photocurrent for colloidal particles is entirely different from that for *R*-centres, and thus these centres may be detected in the presence of one another even though their absorption bands completely overlap. The broad *R*′-band, formed by intense arc-light irradiation of additively coloured crystals, is shown by this method to be due, in the general case, neither to colloidal metal nor to any large amount of *R*-centres. Only when the original *F*-centre concentration was very high, was a colloidal photoconductance band observed, and the photoconductance band characteristic of *R*-centres was always decreased upon formation of the *R*′-band. The centres responsible for the *R*′-band are, except in extreme cases, probably of size intermediate between the "atomic" centres, such as *F*-, *R*- and *M*-centres, and colloidal particles. A.

548.7

5724. Electron tunnelling within insulators. J. J. Markham. *Defects in crystalline solids* [*Bristol*] 304–16. See Abstr. 5707 (1955).

Tunnelling processes within insulators are classified into two groups. The first is pure tunnelling which occurs when an electron jumps from one lattice imperfection to an identical one nearby. No energy dissipation is involved and the process is similar to the conventional case in one dimension. The second type, radiative tunnelling, occurs when an electron jumps to a dissimilar imperfection. The electron now is not in an eigenstate, hence it emits radiation and drops to a lower level. A general equation is derived, using standard perturbation theory, which shows under what conditions radiative tunnelling occurs. The equations indicate that detailed knowledge of the imperfections the electron comes from and goes to is needed before one may make calculations on radiative tunnelling. A simple generalization of one-dimensional tunnelling does not apply to this case. Recently, radiative tunnelling has been observed in KCl and KBr. The formulism suggests that when *F*′-centres are formed from excited *F*-centres the energy is radiated in the form of phonons. This type of reaction has been observed in KBr. A.

548.7 : 536.212.3

5725. The thermal conductivity of irradiated dielectric crystals at low temperatures. R. Berman, E. L. Foster and H. M. Rosenberg. *Defects in crystalline solids* [*Bristol*] 321–7. See Abstr. 5707 (1955).

The measurement of the thermal conductivity of dielectric crystals at low temperatures before and after various radiation doses is a very sensitive method of detecting the damage done to the crystal lattice by the irradiation. Experiments have been made on diamond and on synthetic sapphires which have been subjected either to neutron irradiation from the Harwell pile or to 1 MeV γ-irradiation. Neutron irradiation considerably decreased the thermal conductivity of both diamond and sapphire, and in the latter case it was possible to deduce the volume of damage produced by a fast neutron as being that occupied by about 10^3 atoms. Gamma-irradiation decreased the thermal conductivity of the sapphire but a saturation effect occurred. For the diamond the γ-irradiation had no noticeable effect on the thermal conductivity. A.

548.7

5726. Stacking faults in close-packed lattices. A. Seeger. *Defects in crystalline solids* [*Bristol*] 328–39. See Abstr. 5707 (1955).

Reviews present knowledge of the energies of

stacking faults in various face-centred and hexagonal close-packed metals. From considerations of the electronic structures it is concluded that monovalent metals and cobalt should have low stacking fault energies, whereas Al, Mg, Zn, Cd, Ni, Pd, Pt should have high stacking fault energies. Estimates of the absolute magnitudes of the stacking fault energies in face-centred cubic metals can be deduced from measurements of twin boundary energies and lead to numerical values of about 40 ergs cm^{-2} for Cu and 200–400 ergs cm^{-2} for Al. It is proposed that absolute values of stacking fault energies in hexagonal close-packed structures may be obtained from a study of the energy of low angle grain boundaries built up from extended dislocations. In suitable cases numerical values for the difference of the stacking fault energies of two metals may be obtained from a study of the concentration dependence of the critical shear stress of binary alloys. A great deal of information on the order of magnitude of stacking fault energies in various metals can be derived from the consideration of extended dislocations and their effects on mechanical properties. The whole body of data so far obtained appears to fit into a consistent picture. A.

548.7

5727. Activation energy problems associated with extended dislocations. G. Schoeck and A. Seeger. *Defects in crystalline solids* [*Bristol*] 340–6. See Abstr. 5707 (1955).

An improved method for calculating line energies of dislocations on the basis of Peierls's model, which supplements the elastic method of Burgers, is outlined. It is applied to the calculation of the energy of constrictions in extended edge and screw dislocations in Al and Cu. Using the results obtained previously on such extended dislocations, the energy increase due to a constriction is obtained by a variational method. An application of these results is given to the problem of cross-slip of screw-dislocations in face-centred cubic lattices. A.

548.7

5728. Lattice vacancies in the alkali metals. D. K. C. MacDonald. *Defects in crystalline solids* [*Bristol*] 383–90. See Abstr. 5707 (1955).

It now appears to be well established that one can observe the influence of lattice defects (of Schottky, Frenkel type or perhaps "crowdions") in several properties of the alkali metals over an appreciable temperature range below the melting point. Measurements of specific heat, electrical conductivity and thermoelectric power are discussed and the influence of pressure also considered. A.

548.7

5729. Jogs in dislocation lines. A. Seeger. *Defects in crystalline solids* [*Bristol*] 391–401. See Abstr. 5707 (1955).

An investigation is made into the geometrical properties of jogs in dislocation lines in various lattices. The concepts of "intersection jogs" and "diffusional jogs" are introduced. It is shown that in lattices with basis these two types will in general have different energetical and geometrical properties. Theoretical estimates of jog energies, based on the results of Seeger and of Schoeck and Seeger [Abstr. 5727] on stacking-fault energies and energies of constrictions in extended dislocations, are compared with experimental results in which jog formation is believed to be an essential feature, namely the temperature dependence of the critical shear stress of single crystals and the high temperature creep of metals. The comparison gives a fair agreement between the experimental data and the theoretical expectations. A qualitative discussion of processes connected with dislocations is given in which jogs may possibly play an important part, including the formation of a latent image along dislocation lines in AgBr. A.

548.7

5730. The interaction of colour-centres and vacancies with dislocations in alkali halide crystals. P. L. Pratt. *Defects in crystalline solids* [*Bristol*] 402–8. See Abstr. 5707 (1955).

Photochemical colouring of alkali halide crystals by X-rays or ultraviolet light occurs at impurity atoms and at mosaic walls in such a way that subsequent heat treatment renders these lattice defects visible under the microscope. The increase in hardness produced in annealed or lightly deformed coloured crystals, first noted by Podachewsky, has recently been confirmed by a number of independent workers. The hardness change is not directly related to the presence of *F*-centres in the coloured crystal, since additive chemical colouring has no effect on the hardness. Clusters of vacant lattice sites may contribute to the hardening if they are present, but it seems more probable that the generation of those vacancies required to form the colour-centres is in fact responsible. A.

548.7 : 771.535

5731. Crystal imperfections and chemical reactivity. T. Evans and J. W. Mitchell. *Defects in crystalline solids* [*Bristol*] 409–19. See Abstr. 5707 (1955).

Imperfections which occur in crystals of silver bromide are described and their connection with photographic sensitivity is emphasized. The application of Frank's theory of the rôle of screw dislocations in crystal growth to tabular microcrystals of silver bromide is discussed and some relevant experimental evidence presented. A.

548.7

5732. The influence of lattice vibrations on the order-disorder transitions of alloys. C. Booth and J. S. Rowlinson. *Trans Faraday Soc.*, **51**, *Pt* 4, 463–7 (*April*, 1955).

The statistical theory of the order-disorder transitions of alloys is modified to include the energy of the thermal vibrations of the atoms about their lattice sites. This treatment allows the effect of the vibrations to be considered independently of the combinatory formula used. As an example, the quasi-chemical approximation for β-brass is discussed, and it is shown that the inclusion of the lattice vibrations augments the calculated discontinuity in the heat capacity from about one-third to about one-half of the observed value. A.

548.7

5733. On the scattering of conduction electrons due to lattice vibrations in polar crystals. I. A. MORITA. *Sci. Rep. Tôhoku Univ. First Ser.*, **38**, *No.* 1, 1–18 (*June*, 1954).

The general theory of scattering is reformulated so as to be applicable to the cases in which there are self-energies and finite damping factors. The result is applied to conduction electrons in polar crystals, and it is shown that, although the interaction of conduction electrons with lattice vibrations in polar crystals is so strong that the perturbation-theoretic methods are inapplicable, the results obtained by using the perturbation-theoretic method, provided that the effective mass due to self-energy is adopted as the electron mass, are almost equal to the results obtained by the use of the present more rigorous theory. A.

548.7

5734. On the theory of radiative transitions of trapped electrons in polar crystals. H. J. G. MEYER. *Physica*, **21**, *No.* 4, 253–68 (*April*, 1955).

A semi-empirical theory is developed using a model in which the crystal is considered to consist of a large number of harmonic oscillators all having the same frequency ω and which are coupled to the impurity centre by a coupling linear in all the co-ordinates of the oscillators. The influence of this coupling is calculated up to the second order of a perturbation calculation. In this approximation explicit expressions for the first three moments of the absorption line and for the first two moments of the emission line are derived. These expressions contain certain intricate expressions consisting of combinations of matrix elements of the coupling operator which are considered as adjustable parameters. From a comparison of the theoretical expressions for the moments with experimental data of *F*-centre absorption and fluorescence it is seen that there is good qualitative agreement between theory and experiment. This agreement would not be present without the inclusion of a higher order of approximation. Thus the Condon approximation which is usually made in these sort of problems is certainly not valid for the case considered here. A.

548.7

5735. Mobility of slow electrons in polar crystals. F. E. LOW AND D. PINES. *Phys. Rev.*, **98**, *No.* 2, 414–18 (*April* 15, 1955).

An intermediate-coupling calculation of polaron-phonon scattering has been carried out by expressing the scattering amplitude directly in terms of matrix elements between exact eigenstates of the Hamiltonian corresponding to the initial and final states of the scattered particle. The basic approximation made is in the use of the rather accurate polaron wave-functions of Lee, Low and Pines for these intial and final states. The result for the mobility, which is only valid in the low-temperature region ($T \ll \theta$) is

$$\mu = \frac{1}{2\alpha\omega}\left(\frac{e}{m}\right)\frac{1}{[1+(\alpha/6)]^3} f(\alpha)\exp(\omega/\kappa T),$$

where α is the coupling constant for the electron-phonon interaction and $f(\alpha)$ is a slowly varying quantity of order 5/4 for $3 < \alpha < 6$. A.

548.7

5736. Reactor and gamma-ray induced coloring in crystalline quartz and Corning fused silica. P. W. LEVY. Letter in *J. chem. Phys.*, **23**, *No.* 4, 764–5 (*April*, 1955).

548.7

5737. Impurity induced color centres in fused silica. A. J. COHEN. Letter in *J. chem. Phys.*, **23**, *No.* 4, 765–6 (*April*, 1955).

548.7 : 537.583

Electron emission and colour centres in ionic crystals. *See Abstr.* 5484

548.7 : 539.132

5738. Electric quadrupole interaction and spin echoes in crystals. T. P. DAS AND A. K. SAHA. *Phys. Rev.*, **98**, *No.* 2, 516–24 (*April* 15, 1955).

Bloom and Norberg and also Hahn and Herzog have observed spin echoes due to electric quadrupole interaction alone and also in the presence of a weak magnetic field in addition to electric quadrupole interaction, with Cl^{35} (spin $I = 3/2$) nuclei in $NaClO_3$-crystal. They have explained these echoes theoretically for the particular case of $I = 3/2$. The spin-echo amplitudes to be expected under the above experimental conditions for nuclei of any general spin in crystals with axial symmetry have been calculated. The opposite case of spin echoes in a strong magnetic field in the presence of weak electric quadrupole interaction is also discussed. The theoretical investigation leads to "slow beats" in this case also. A.

548.7 : 539.132

5739. Spin echoes with four pulses—an extension to *n* pulses. T. P. DAS AND D. K. ROY. *Phys. Rev.*, **98**, *No.* 2, 525–31 (*April* 15, 1955).

Following Das and Saha's method, the response of a nuclear spin system to four r.f. pulses has been analysed by using the classical Bloch equations. The calculations enable one to obtain a recursion formula for the number of echoes to be expected with n pulses. Besides, the calculations also yield several other results important from the experimental view. Thus, they provide a method for obtaining T_1, the spin-lattice relaxation time, from primary echo measurements alone, and also give an idea of the order of correction necessary in a measurement of T_2, the "spin-spin relaxation time," by observation of primary echoes with successive paired pulses of gradually changing intervals. A.

548.7

5740. Nuclear magnetic resonance spectrum of B^{11} in kernite. H. H. WATERMAN AND G. M. VOLKOFF. *Canad. J. Phys.*, **33**, *No.* 5, 156–75 (*May*, 1955).

The r.f. spectrum of B^{11} in a single crystal of $Na_2B_4O_7.4H_2O$ (kernite) was examined experimentally as the monoclinic crystal is rotated in an external magnetic field of 7060 gauss in turn about each of three axes (*b*, *c* crystallographic axes, and a third perpendicular direction) held normal to the magnetic field. A maximum of 21 lines (some of which show small additional splitting) was observed, which reduce to 11 when the *b* symmetry axis was perpendicular or parallel to the magnetic field. The results are interpreted in terms of four essentially non-equivalent B^{11} sites in kernite characterized respectively by

quadrupole coupling constants $|eQ\phi_{zz}/h| = 0{\cdot}645 \pm 0{\cdot}003$, $0{\cdot}588 \pm 0{\cdot}003$, $2{\cdot}563 \pm 0{\cdot}007$, $2{\cdot}567 \pm 0{\cdot}010$ Mc/s, and asymmetry parameters $\eta \equiv (\phi_{xx}-\phi_{yy})/\phi_{zz} = 0{\cdot}54 \pm 0{\cdot}01$, $0{\cdot}60 \pm 0{\cdot}02$, $0{\cdot}163 \pm 0{\cdot}010$, $0{\cdot}116 \pm 0{\cdot}010$. The orientations of the principal axes of the four ϕ_{ij} tensors were also determined. These observations on boron are consistent with previous X-ray results, but preliminary observations on Na^{23} in kernite contradict previous X-ray position assignments. A.

548.7 : 535.347

Infrared dichroism and crystal structure. *See Abstr.* 5330

548.7 : 539.132 : 535.343

Infrared spectrum and the structure of the low-temperature phases of crystalline HCl, HBr, and HI. *See Abstr.* 5320

548.73/.74

X-ray and electron investigation of materials. *See also under* "Structure of solids." Decimal classification 539.26/.27.

548.73

5741. X-ray diffraction by polycrystalline materials. Edited by H. S. Peiser, H. P. Rooksby and A. J. C. Wilson. *London: The Institute of Physics* (1955) 725 *pp.*

Review in *J. sci. Instrum.*, **32**, *No.* 5, 193 (*May*, 1955). "This volume is the latest addition to the Physics in Industry series of monographs. It is divided into three parts: experimental techniques, interpretation of data, and practical uses of the techniques in different fields. It contains over 250 figures, many references and an Appendix which includes useful tables."

548.732

5742. The theory of Kikuchi patterns. Y. Kainuma. *Acta cryst.*, **8**, *Pt* 5, 247–57 (*May*, 1955).

Laue's original theory (1935) of Kikuchi patterns cannot explain the fact that whether the lines appear black or white depends upon the direction of the incident beam. Although he proposed a revised theory (1948), Laue did not obtain any conclusion which could be compared with experiment. The present author has developed Laue's revised theory and discusses such conclusions. A.

548.732

5743. The diffraction of X-rays by a cylindrical lattice. II. E. J. W. Whittaker. *Acta cryst.*, **8**, *Pt* 5, 261–5 (*May*, 1955).

For Pt I, see Abstr. 4184 (1955). Previous theoretical work on this subject is extended to determine the positions and profiles of the diffuse reflections from a cylindrical lattice. These are computed in the case when the scattering matter is concentrated at the lattice points, and the necessary formula is derived for the case when an assemblage of atoms is associated with each lattice point. Two of the conclusions reached by Jagodzinski and Kunze are shown to be either erroneous or irrelevant. A.

548.732

5744. The diffraction of X-rays by a cylindrical lattice. III. E. J. W. Whittaker. *Acta cryst.*, **8**, *Pt* 5, 265–71 (*May*, 1955).

Pts I and II have dealt with the mathematical theory of diffraction by circular cylindrical lattices. The results have now been confirmed by model optical diffraction experiments, and this method has been used to investigate diffraction by spiral cylindrical lattices and incomplete circular cylindrical lattices. A.

548.732

5745. Verification of Bragg's law by the use of microwaves. R. A. Allen. *Amer. J. Phys.*, **23**, *No.* 5, 297–8 (*May*, 1955).

An experiment which demonstrates the Bragg method of X-ray spectrometry using 12 cm microwaves and a model crystal. A.

548.733

5746. The "Norelco" X-ray diffractometer. W. Parrish, E. A. Hamacher and K. Lowitzsch. *Philips tech. Rev.*, **16**, *No.* 4, 123–33 (*Oct.*, 1954).

The "Norelco" X-ray diffractometer, which has now been commercially available for some years, is a completely re-designed version of the Geiger counter X-ray spectrometer formerly described [Abstr. 1238 (1949)]. The new version incorporates an improved resolution of diffraction lines ($CuK\alpha_1$-α_2 separation visible at $2\Theta > 30°$), better accuracy in the measurement of diffraction angles (readings to $0{\cdot}01°$ in 2Θ) and of relative line intensities, and a higher diffraction angle range (up to $2\Theta = 165°$). These improvements are due to the use of a new X-ray optical system together with a normal basic diffraction unit having a high-powered water-cooled X-ray tube with mica-beryllium windows, and to the design of a high precision mechanical Geiger counter goniometer. The new X-ray optics is based on the use of a line-focus source. Owing to this feature and to a vertical arrangement of the X-ray tube and goniometer circle, it is possible to use two goniometers and two normal photographic powder diffraction cameras simultaneously with the four window X-ray tube of one basic diffraction unit. Scanning speeds varying from $\frac{1}{8}$ to 2° per minute can be selected; alternatively an automatic stepwise movement of the goniometer is possible. Apart from automatic recording, either continuously or point-by-point, the electronic circuits developed for the instrument permit the application of special counting methods. The various counting and recording methods will be described in a following article. A.

548.734

5747. X-ray measurement of the lattice spacing of AgBr in photographic emulsion with a latent image. W. Waidelich. *Z. Phys.*, **140**, *No.* 3, 241–61 (1955) In German.

Photographic film was passed rapidly through the specimen position in a back-reflection camera, and the spacing of the (620) planes was determined for various times of exposure of the film to either light or X-rays. A small systematic increase of spacing was observed in each of five films for moderate exposure, but there was a decrease on heavy over-exposure. A. R. Stokes

548.734

5748. Some properties of Fourier strips, with applications to the digital computer. J. M. Robertson. *Acta cryst.*, **8**, *Pt* 5, 286–8 (*May*, 1955).

By a simple modification the number of figures

which it is necessary to print in the usual Beevers–Lipson type of Fourier strip may be reduced to one quarter, if the summation interval is correctly chosen. This modification may be useful if it is desired to produce strips for finer axial sub-division, and it has obvious applications in simplifying a digital computer previously described. A.

548.736

5749. X-ray diffractometry of radioactive samples. T. R. KOHLER AND W. PARRISH. *Rev. sci. Instrum.*, **26**, *No.* 4, 374–9 (*April*, 1955).

Geiger counter X-ray diffractometer patterns of samples with moderate to high radioactivity give a high background, which reduces the precision of the X-ray-line intensity and profile measurements. The large amount of lead shielding required to reduce the background is not practical in modern precision goniometers and could not bring as great a reduction as can be achieved with scintillation or proportional counters using pulse-height discrimination and no shielding. This paper describes a technique using a scintillation counter which permits the measurement of X-ray patterns from strongly radioactive specimens. A scintillation counter with 0·56 in. × 0·16 in. × 0·017 in. thick NaI.Tl crystal, 0·005 in. Be window and DuMont 6291 photomultiplier is described, which reduced the background of an 84 mr.hr^{-1}10 cm^{-1} Co^{60} sample from 785 c/sec, measured with a Geiger counter, to 26 c/sec and increased the sensitivity to Cu$K\alpha$ by a factor of about 2·5 to 3. A.

548.736.3

5750. A magneto-X-ray study of magnetite at 78°K. S. C. ABRAHAMS AND B. A. CALHOUN. *Acta cryst.*, **8**, *Pt* 5, 257–60 (*May*, 1955).

The X-ray diffraction pattern produced by a small single crystal of magnetite after cooling through the transition at 119°K has been examined. It is demonstrated, by using orientated magnetic fields during the cooling process, that up to six different domain orientations are present in the crystal at 78°K. This number of domain orientations can be produced only if the symmetry of the low-temperature phase of magnetite is orthorhombic or lower. A.

548.736.3 : 541.182.3

5751. X-ray diffraction study of silver iodide aerosols. J. E. MANSON. *J. appl. Phys.*, **26**, *No.* 4, 423–5 (*April*, 1955).

A source of silver iodide aerosols has been studied to determine the effect of the temperature of generation on the crystal structure of the particles in the aerosol output. Sampling was done by use of a novel thermal precipitator which gave samples in the proper form for direct analysis in a Debye–Scherrer X-ray diffraction camera. Patterns were obtained indicating the presence of both cubic and hexagonal modifications (ZnS and ZnO type). As the source temperature was raised, an increase of the proportion of hexagonal particles was observed, 95% hexagonal particles resulted when the source was operated at 800°C. An explanation of this behaviour is proposed. A.

548.736.4

5752. Proposed structure of certain spinels at high temperature. W. T. HOLSER. Letter in *J. chem. Phys.*, **23**, *No.* 4, 764 (*April*, 1955).

Discusses dependence on temperature of the fraction λ of Fe^{3+} ions (in spinels like $Fe_2^{3+}Cu^{2+}O_4$) in *A* sites (4-co-ordination). With increasing temperature λ might change either by disordering of cations among *A* and *B* (6-co-ordination) sites (giving $\lambda = \frac{1}{3}$), or else by a gradual change from the inverse ($\lambda = \frac{1}{2}$) to the normal ($\lambda = 1$) structure, without internal disordering among *A* and *B* sites in a domain of one structure. Comparison with experiment favours the latter process. J. HAWGOOD

548.736.4 : 548.74

5753. X-ray and neutron diffraction study of ferroelectric $PbTiO_3$. G. SHIRANE, R. PEPINSKY AND B. C. FRAZER. Letter in *Phys. Rev.*, **97**, *No.* 4, 1179–80 (*Feb.* 15, 1955).

The tetragonal $PbTiO_3$ structure was studied for its own sake and because it is believed to be isomorphous with tetragonal $BaTiO_3$ whose precise structure is unknown. X-ray and neutron diffraction results led to atomic parameters which resembled one of the two sets put forward by Evans (unpublished) for $BaTiO_3$. It was considered unwise, however, to draw definite conclusions about the $BaTiO_3$ structure until further data are available. J. THEWLIS

548.737 : 535.347

5754. Infrared spectrum and structure of collagen. G. N. RAMACHANDRAN. Letter in *J. chem. Phys.*, **23**, *No.* 3, 600–1 (*March*, 1955).

It is pointed out that the data of Sutherland *et al.* [Abstr. 639 (1955)] on dichroism of infrared bands of collagen are in accordance with the structure suggested by Ramachandran and Kartha. The dichroism calculated on the basis of this structure shows good agreement with the experimental data and the molecular angles calculated agree with X-ray results. A. J. TAYLOR

GEOPHYSICS 55

550.385

5755. A semi-annual periodicity in the beginnings of recurrent magnetic storm series. J. H. RUSH. Letter in *Nature* [*London*] **175**, 517–18 (*March* 19, 1954).

Records of geomagnetic disturbances during the seven sunspot cycles from 1884 to 1954 reveal a strong tendency for the initial disturbance of a 27-day recurrent series to occur near January or July; final disturbances of such series show this tendency only weakly. This result was obtained from graphs of 3-day moving averages of the magnetic character figure *C* through 48 years of declining sunspot activity. The statistical method employed is outlined in detail and the results are diagrammatically represented. A. BEER

550.510.535

5756. Information obtained with the aid of ionization charts. R. EYFRIG, E. HARNISCHMACHER AND K. RAWER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 4, 446–8 (*Jan.* 24, 1955) In French.

The geomagnetic control of the *F*2-layer is apparent

for all latitudes up to 70° during the hours of daylight only; it is less clear at night. It appears also that the geomagnetic control is different in the N and S hemispheres. Some results are also given for the N polar zone, and for the "auroral E" layer. G. M. BROWN

550.839 : 539.16

5757. Aerial prospecting for radioactive materials. E. A. GODBY, S. H. G. CONNOCK, J. F. STELJES, G. COWPER AND H. CARMICHAEL. *Atomic Energy Canada Rep.*, *No.* 13, 31 *pp.* (*March* 13, 1952).

Aircraft have been used in Canada for prospecting for radioactive ores since the summer of 1948 when a Norseman aircraft was fitted with a small airborne Geiger counter and was flown briefly over pitchblende deposits in northern Saskatchewan. During 1949 and 1950, ion-chambers, improved G.M. counters employing an anti-coincidence arrangement, and scintillation counters were used in practical aerial surveys. Tests were made over standard radium and ore sources and over natural pitchblende deposits in northern Saskatchewan and the Northwest Territories. In a period of two years the optimum survey height was raised from 200 ft using ordinary G.M. counters or ion-chambers to 550 ft using modern scintillation counters. It is concluded that a scintillation detector system is capable of economic and successful prospecting from the air. A.

ATMOSPHERE . METEOROLOGY 551.5

551.501.8 : 551.57

5758. Precipitation echoes and clouds. M. G. H. LIGDA. *Bull. Amer. Meteorol. Soc.*, **36**, *No.* 2, 47–52 (*Feb.*, 1955).

The size, shape and character of radar echoes caused by precipitation as viewed on PPI scopes are related to the clouds in which the precipitation develops. Photographs of PPI scopes showing precipitation echoes of various types are shown together with photographs taken from aircraft of the clouds in the immediate vicinity of the precipitation. Such a presentation is an aid in the interpretation of radar precipitation echoes. A.

551.508.71

5759. A theory of the ventilated psychrometer based on the thermodynamics of irreversible processes. D. J. BOUMAN. *Tellus*, **6**, *No.* 4, 399–404 (*Nov.*, 1954).

It is shown that the thermodynamics of irreversible processes as developed by Prigogine (1947) and de Groot (1951) offer the possibility of deriving the psychrometric equation without using pseudothermostatic reasoning. A.

551.508.8

5760. Time constants of radiosonde thermistors. E. SION. *Bull. Amer. Meteorol. Soc.*, **36**, *No.* 1, 16–21 (*Jan.*, 1955).

Details of the experimental technique are presented whereby thermal time constants were determined at various air speeds up to 2 700 ft/min. Results are presented graphically to show the effect of time constant versus air speed with pressure and the corresponding average ambient temperature as encountered in the "average" atmosphere as parameters. A.

551.508.96

5761. A panoramic ionospheric recorder for the study of travelling disturbances in the ionosphere. L. H. HEISLER. *Austral. J. appl. Sci.*, **6**, *No.* 1, 1–6 (*March*, 1955).

The recorder covers the range 1 to 15 Mc/s with a fast scan of 7½ or 15 sec. New circuits have been evolved and an unconventional method of recording used to make the equipment especially suitable for the study of movements in the ionosphere. A panoramic display of each scan is provided and this is used for visual monitoring of the recording programme. A.

551.508.96

5762. Instrumentation for the continuous measurement of certain ionospheric echo characteristics. R. W. PARKINSON. *Rev. sci. Instrum.*, **26**, *No.* 4, 319–23 (*April*, 1955).

A method is described for continuously measuring the polarization and other parameters of radio pulse echoes reflected from the ionosphere in very compact form. Time-varied intensity modulation is employed to resolve split echoes with respect to height of reflection. A.

551.510.535

5763. The physics of the ionosphere. *London: The Physical Society* (1955) 406 *pp.*

Report of a Physical Society conference held at the Cavendish Laboratory, Cambridge, September, 1954. The volume contains four parts, namely: I. The lowest ionosphere. II. Irregularities and movements. III. The $F2$-layer. IV. The mathematics of wave propagation through the ionosphere. Fifty papers in all are printed and these are abstracted individually.

551.510.535

5764. The lowest ionosphere. A. H. WAYNICK. *Physics of the ionosphere* [*Cambridge*] 1–13. See Abstr. 5763 (1955).

Introduction to Pt I of this conference. An attempt is made to summarize the recent radio data which may be utilized as a guide to the possible physical characteristics of the lowest ionosphere. The consideration of anomalies and short period phenomena are purposefully avoided in an effort to deduce gross characteristics. The apparent current state of work concerned with four physical characteristics of the lowest ionosphere which are based in part on this evidence, and in part, on available, pertinent rocket data is briefly described. The factors considered are collision frequency, recombination, E-region electron density distribution, and D-region electron density distribution. A.

551.510.535

5765. Ionospheric layer formation under quasi-stationary conditions. E. V. APPLETON AND A. J. LYON. *Physics of the ionosphere* [*Cambridge*] 20–39. See Abstr. 5763 (1955).

A modified theory of ionospheric layer formation is described in which the value of the spatial maximum of electron density N_m and its atmospheric height $z(N_m)$ are given explicitly. The work owes much to Chapman's classical treatment of the theory of

ionospheric layer formation, but yields results which are more directly applicable to the type of problems encountered in practice. It may be used, for example, in cases where the atmospheric properties, such as temperature and recombination coefficient, vary with height, or where the layer is distorted by atmospheric tides. It has long been recognized that the theory of ionospheric layer formation is chiefly complicated by the fact that, as the sun's zenith distance χ alters in the course of the day, the level of maximum ionization N_m lags behind the level of maximum electron production q_m. It is shown that the distance a between these two levels is equal to $(\tan\chi d\chi/dt)/2\alpha N_m$, where α is the recombination coefficient and t is the time. An approximate solution of the continuity equation is used to investigate detailed features of the N, or N_m, curves near noon, and also to derive second-order approximations for a and for N_m. With the aid of these results, theoretical curves of the diurnal variations of N_m and the height at which it occurs may readily be computed for any latitude and time of year. The formulae are valid for the greater part of the solar day and include "Chapman function" corrections where necessary. A number of examples illustrating the significance of the "time of relaxation" of an ionized layer $1/2\alpha N_m$ are quoted. The distorting influence of vertical drift on both N_m and $z(N_m)$ for an ionized stratum of E-layer type is shown, for example, to depend on two factors only, namely the vertical drift characteristics and the time of relaxation of the ionized medium. A.

551.510.535

5766. Solar X-ray emission and the height of *D* layer during radio fade-out. H. FRIEDMAN AND T. A. CHUBB. *Physics of the ionosphere* [*Cambridge*] 58–62. See Abstr. 5763 (1955).

Rocket measurements show that Lyman α radiation of hydrogen is the major source of ionization in normal D-layer and that solar X-rays contribute to the uppermost portions. Evidence exists that X-rays as short as 1–2 Å together with enhanced Lyman α radiation are generated during a solar flare. The largest flares are accompanied by sudden phase anomalies which indicate a lowering of the reflecting ceiling for long waves by as much as 15 km. To produce the necessary ionization at the lower levels $L\alpha$ intensity would need to increase by 10^4 during the flare, reaching a peak value of 10^3 erg cm^{-2} sec^{-1}. An X-ray flux of only 10^{-5} erg cm^{-2} sec^{-1} would form the required reflecting layer at 60 km. A.

551.510.535

5767. A survey of existing knowledge of irregularities and horizontal movements in the ionosphere. J. A. RATCLIFFE. *Physics of the ionosphere* [*Cambridge*] 88–98. See Abstr. 5763 (1955).

Introduction to Pt II of this conference. With bibliography.

551.510.535

5768. On the fluctuations of the frequency limit of the *F*2-layer during undisturbed conditions in the ionosphere. W. BECKER. *Physics of the ionosphere* [*Cambridge*] 101–3. See Abstr. 5763 (1955) In German.

Supplementary evidence is given that the deviations of f_0F2 from the respective monthly median values are primarily due to mechanical or thermal causes and not to intensity variations of the ionizing agent. A.

551.510.535

5769. On the interpretation of the movement of field strength fluctuations as ionospheric wind. H. BERG. *Physics of the ionosphere* [*Cambridge*] 104–12. See Abstr. 5763 (1955).

If the ionospheric irregularities are randomly distributed (in the forms of "bumps") then an amplitude pattern of random shape is produced on the ground. A uniform translation of the system of irregularities, which may reasonably be called a "wind," shows itself as a translation of the amplitude pattern. A series of pairs of differences, t_x and t_y, between the times of passage of selected maxima or minima over aerials placed at the corners of a right-angled triangle, should lie on a straight line when plotted on a (t_x, t_y) diagram, if the wind vector is constant. According to Pütter the true wind vector can be determined from this line. If, however, the irregularities are arranged in straight lines, as, for example in waves, then a linear interference pattern would result on the ground. A translation of this would give rise to points which coincide in the (t_x, t_y) diagram. In actual fact the points will be spread within an approximately circular region because of errors of measurement, or because of small variations in the velocity normal to the lines of interference. In this case, not the velocity of the "wind," but the velocity of the linear system of irregularities normal to its structure is obtained. With a wave-like disturbance this can be markedly different from the wind vector. Of the series investigated, with 5–15 measured pairs of t_x, t_y within 1–3 minutes, about 15% gave results which lay reasonably on a straight line. In other cases the cluster of dots representing t_x and t_y was elongated so that its extension was different in different directions. In most of the remainder, however, a nearly circular cluster of dots was obtained. A.

551.510.535

5770. Some observations of ionospheric movements. K. BIBL, E. HARNISCHMACHER AND K. RAWER. *Physics of the ionosphere* [*Cambridge*] 113–18. See Abstr. 5763 (1955).

Echoes at vertical incidence can be distinguished from those of more than 10° obliquity by a normal ionosonde which is equipped with an aerial switching arrangement. Whilst E_s echoes have been found to be vertical, diffuse echoes from the $F2$-layer are often oblique. Also in the case of a doubled F trace the upper trace always corresponds to an oblique direction. The interpretation of echo amplitude observations in terms of a flat ionosphere is not satisfactory. One must take account of the "ripples" by which focusing effects may be introduced. The evaluation of a series of night observations shows that the radius of curvature of the reflecting F-layer is very often three times the layer height. The horizontal movement of these "ripples" may be obtained by the Pawsey–Krautkrämer method. An automatic device gives directly the amplitude and direction in triangular co-ordinates. Besides these horizontal movements vertical ones also seem to exist. One finds these on motion-picture ionograms. The movement is always from higher to lower frequencies

in the ionogram, i.e. for the true height from the *F*- to *E*-layer. The speed is of the same order as that of sound. The phenomenon is most common during the sunlit hours. It is not impossible that the observed movement may have a horizontal component; in that case there must be a dissymmetry with regard to the direction of propagation. Besides the information obtained on movements through these methods, the existence of these phenomena is important for the interpretation of normal ionospheric observations, especially for the evaluation of ionograms as well as for absorption measurements. A.

551.510.535

5771. An empirical study of random functions which arise in the interpretation of ionospheric movements. B. H. Briggs and E. S. Page. *Physics of the ionosphere* [*Cambridge*] 119–22. See Abstr. 5763 (1955).

An empirical study is made of the probability distribution of the difference in position of corresponding maxima of two random functions of known high correlation. An electronic computer was used to construct artificial random functions of known statistical behaviour from random normal deviates. The results are used to deduce certain properties of the "lines of maxima" of a two-dimensional random function, which are needed in the study of ionospheric movements. A.

551.510.535

5772. The variability of time shifts in measurements of ionospheric movements. B. H. Briggs and M. Spencer. *Physics of the ionosphere* [*Cambridge*] 123–35. See Abstr. 5763 (1955).

In the measurement of ionospheric movements by the method which uses closely spaced receivers, the time shifts between maxima or minima of signal amplitude at three points are observed. These time shifts are produced by the drift of an amplitude pattern past the receiving points, and the velocity of this pattern is closely related to movements of ionization in the ionosphere. When the records are examined it is found that there is considerable variability in the magnitudes of the individual time shifts, and it is of interest to know whether this corresponds to a true variation of the drift or whether it is a purely statistical effect inherent in the method. In this paper, some theoretical and experimental results which bear on this question are presented. It is shown that the fluctuations in time shifts are larger than can be explained by the drift of an irregular amplitude pattern past the receiving points with a constant velocity. To explain this it is assumed that the pattern moves with a constant velocity but changes in form as it moves. It is shown that the experimental results can be explained on this hypothesis, provided it is also assumed that, on some occasions, the amplitude pattern may be anisotropic. A.

551.510.535

5773. Interpretation of observed *F*2 "winds" as ionization drifts associated with the magnetic variations. D. F. Martyn. *Physics of the ionosphere* [*Cambridge*] 163–5. See Abstr. 5763 (1955).

It is shown that the diurnal, seasonal diurnal and magnetic disturbance diurnal "winds" in the *F*2-region are consistent, in phase, amplitude and spatial distribution, with the view that they are drifts of (neutral) ionization produced by a potential (electric) field in the main conducting region of the ionosphere. This field, which is communicated to the *F*2-region along the highly conducting lines of magnetic force, is that which is now known to be associated with the magnetic quiet day and disturbance variations, when allowance is made for the Hall conductivity of the main conducting region. A.

551.510.535

5774. Travelling disturbances in the ionosphere. R. E. Price. *Physics of the ionosphere* [*Cambridge*] 181–90. See Abstr. 5763 (1955).

The velocity and direction of travel of disturbances in the ionosphere have been measured at Perth, Western Australia, using a system of three spaced constant frequency pulsed transmitters. Results indicate a variation of the rate of travel of the disturbances from low values up to 20 km.min^{-1}. The horizontal direction of travel is shown to vary between 90 and 210°E of N in the summer months and between 300 and 90° E of N in the winter months. Correlations were sought between the mean daily wind speed, the number of disturbances per day, and the mean daily size of the disturbances with the auroral activity observed at MacQuarie Island (latitude 54° S, longitude 159° E) and the *K* index of magnetic activity at Watheroo (30° S, 116° E) but were not observed. The measurements are shown to be in good agreement with similar observations made at Sydney, N.S.W., although the measured speeds suggest a time lag of only 7–13 hr between disturbances in Perth and those observed in Sydney next day. Suggestions are put forward as to the nature of this effect. A.

551.510.535

5775. A method for studying large-scale irregularities in region *E* of the ionosphere. R. L. Schrag. *Physics of the ionosphere* [*Cambridge*] 202–11. See Abstr. 5763 (1955).

Describes experimentally observed multiple-hop echo focusing phenomena due to *E*-region irregularities. These phenomena, detected principally during winter night-time hours, were of a transient nature with lifetimes ranging from 6 to 50 min. An analysis, based on simple ray optics, indicates that the irregularities responsible for the focusing effects were "large-scale," and had radii of curvature of the order of 1 000 km. Estimates of the probable dimensions are presented. The experiments were conducted at vertical incidence, utilizing 150 kc/s pulsed radio signals. A.

551.510.535

5776. A survey of present knowledge of the *F*2 region. D. F. Martyn. *Physics of the ionosphere* [*Cambridge*] 212–18. See Abstr. 5763 (1955).

Introduction to Pt III of this conference.

551.510.535

5777. Storm phenomena and the solar cycle variations of the *F*2 layer ionization at noon. E. V. Appleton and W. R. Piggott. *Physics of the ionosphere* [*Cambridge*] 219–28. See Abstr. 5763 (1955).

The sensitivity of the *F*2-layer to changes in solar

activity varies greatly with position and season, suggesting that it is influenced by changes in the atmosphere. Comparisons between the values of f_0F2 near noon for magnetically quiet and disturbed days, and for monthly averages over two solar cycles, show characteristic perturbations with seasonal variations similar to those of ionospheric storms. Differences in the incidence of magnetic storminess in the rising and falling parts of the solar cycle appear to be sufficient to account for the observed multiple values of f_0F2 at constant sunspot number. The latter is, however, a poor index of the incidence of photo-ionizing radiation during any one month. A.

551.510.535

5778. The ionospheric *F*2 region. R. J. Havens, H. Friedman and E. O. Hulburt. *Physics of the ionosphere* [*Cambridge*] 237–44. See Abstr. 5763 (1955).

From rocket measurements the air pressure and temperature were observed to 219 km; O_2^+ and O^+ were present from 107 to 219 km, NO^+ and CN^+ from 107 to 124 km; the ratio of O to O_2 increased above 100 km; the electron density increased from 90 to 219 km with no pronounced dip above *E*; X-rays from 8 to 100 Å were in the solar spectrum of intensity 0·1 to 1 erg.cm^{-2}.sec^{-1}, variable with corona activity. Extrapolating the pressure, atmospheric composition and electron density to above 300 km and the solar spectrum to beyond 300 Å, a quantitative theory is worked out which attributes *E* to wavelengths below 100 Å, the ionization between *E* and *F*2 to wavelengths 100–200 Å, and *F*2 to wavelengths longer than 200 Å. The rapid recombination in *E* is attributed mainly to charge exchange from O^+ to O_2, and the slower recombination in *F*2 to photo-recombination. A.

551.510.535

5779. Geomagnetic distortion in the *F*2 layer. K. Maeda. *Physics of the ionosphere* [*Cambridge*] 245–53. See Abstr. 5763 (1955).

The following curves are presented: (i) Geomagnetic latitude distributions of seasonal average of the noon f_0F2 and $h'F2$ for three geomagnetic longitudes ($\Lambda = 0°$, 90° and 270°, 180°). The most outstanding features are (*a*) depression of f_0F2 near the geomagnetic equator, (*b*) rise of $h'F2$ near the geomagnetic equator. (ii) Geomagnetic latitude distributions of seasonal average of the midnight f_0F2 and $h'F2$. The following are pointed out: (*a*) low level of $h'F2$ and symmetry around the equator, (*b*) low value of f_0F2 on the winter hemisphere and higher value of f_0F2 on the summer hemisphere. It seems that the time duration from sunset to midnight controls the level of f_0F2. (iii) Seasonal variation of monthly median of noon $h'F2$. The main features are (*a*) high value in the summer solstice on the middle and higher geomagnetic latitudes, (*b*) each one peaks in the summer and winter solstices on the low geomagnetic latitude. (iv) Daytime variation of f_0F2. The shapes of the variation curves are systematically distributed on the geomagnetic latitude. A discussion and a possible interpretation of some characteristics are presented from the viewpoint of the dynamo theory of geomagnetism. A.

551.510.535

5780. Theory of height and ionization density changes at the maximum of a Chapman-like region, taking account of ion production, decay, diffusion, and tidal drift. D. F. Martyn. *Physics of the ionosphere* [*Cambridge*] 254–9. See Abstr. 5763 (1955).

Formulae are derived for $\partial z_m/\partial t$ and $\partial N_m/\partial t$ (the time variations of the height and ionization density respectively, at the maximum of a Chapman-like region), taking account of ionization production, decay, diffusion, vertical drift, and of height gradient in each of these influences. It is shown how the height gradient of drift appears to account adequately for main features of the geomagnetic anomalies in the world contours of z_m and N_m; the anomalies are further enhanced by the virtual disappearance of vertical diffusion of ionization at the magnetic equator. A.

551.510.535

5781. Geomagnetic anomalies of the *F*2 region and their interpretation. D. F. Martyn. *Physics of the ionosphere* [*Cambridge*] 260–4. See Abstr. 5763 (1955).

Curves are given showing the world distribution of f_0F2 at two sunspot epochs and for the three seasons. The anomalies thus revealed are classified. The dynamo theory of the magnetic variations, as developed by Baker and Martyn, is used to link the observed *F*2-morphology with the morphology of the magnetic variations at both quite and disturbed times. A quantitative interpretation is made of the main *F*2-anomalies such as the morning rise and evening fall in *F*2-height, the symmetry about the geomagnetic equator, and the anomalous diurnal variation of *F*2-height and density in the anomalous equatorial zones. A.

551.510.535

5782. Ionospheric *F*2 variations associated with geomagnetic disturbances at the equatorial zone. S. Matsushita. *Physics of the ionosphere* [*Cambridge*] 265–9. See Abstr. 5763 (1955).

The disturbance daily variations and the storm-time variations in the minimum virtual height and in the critical frequencies of the *F*2-layer at Huancayo have been studied. A sharp maximum of the disturbance daily variation occurs at about 05 hr. The S_D variation for the geomagnetic horizontal component at Huancayo was also examined. That variation has some peculiarity compared with at moderate latitudes. This result is explained by the S_D current system calculated by the dynamo theory, taking into consideration the anisotropic electrical conductivity. The sharp maximum in the disturbance daily variation of $h'F2$ at Huancayo is explained by theoretical consideration of the drift produced by the electric field of the calculated S_D and the earth's magnetic field. A.

551.510.535

5783. Information about the *F*2 layer taken from ionization maps. K. Rawer. *Physics of the ionosphere* [*Cambridge*] 270–5. See Abstr. 5763 (1955).

The usual presentation of *F*2-data in ionization maps is a discontinuous one (system of four geomagnetic zones). A continuous presentation with two principal zones (chosen according to magnetic inclination) and two intermediate zones of linear interpolation may be considered as a first step to a

continuous, world-wide presentation taking account of all existing data. The interpolation formula has been tested with the ionization maps obtained from the data. It has been recently modified according to these experiences and now makes use of three "principal zones." A method to reach a more complete presentation is indicated. The discussion in terms of "local time" seems to be advantageous; further, presentation in universal time may be obtained by a simple transformation. It is emphasized that the use of observations obtained during the month in question is far from affording a satisfactory solution. There are two sources of information (an actual one and a theoretical one, the latter being the sum of past experience), and one should use both. Theoretical information will thus increase, thanks to practical prediction work. A.

551.510.535

5784. A method for determining the variation of electron density with height [$N(z)$ curves] from curves of equivalent height against frequency [(h', f) curves]. K. G. Budden. *Physics of the ionosphere* [*Cambridge*] 332–9. See Abstr. 5763 (1955).

The equivalent height of reflection $h'(f)$ for radio-waves of frequency f incident vertically on the ionosphere is given by

$$h'(f) = \int_0^{z_0} \mu'(N, f)dz$$

where z is height above the ground, z_0 is the height of reflection, and $N(f)$ is the electron density at the height z. μ' is the ratio of the velocity of electromagnetic waves in free space to the group velocity of the radio-waves, and is called the "group refractive index." This is an integral equation whose solution gives the function $N(z)$. It is well known that, when the earth's magnetic field and the effect of electron collisions are neglected, the form of the function μ' is such that the equation may be reduced to Abel's equation, for which the solution is known. Such a simplification is not possible if the effect of the earth's magnetic field is allowed for, and the equation must then be solved numerically. The present paper gives a method of doing this. The method consists in replacing the integral by a discrete sum. By a suitable choice of variables, this may be expressed as the product of a $n \times n$ triangular matrix and a column matrix of n elements. The triangular matrix is then inverted, and from the resulting equation the function $N(z)$ can be found. Calculations using this method have been made on the EDSAC automatic digital computer at Cambridge. In practice a table of numbers is calculated for each observing station, and is then available for the analysis of unlimited (h', f) data from that station. The calculation is comparatively straightforward. The method can only be used when $N(z)$ is a monotonic function of z. The accuracy is determined by the size of the interval in the discrete sum used to replace the integral, and could be made as high as desired by choosing a small enough interval. A.

551.510.535 : 523.164

5785. Investigation of F region drift movements by observations of radio star fading. A. Maxwell. *Physics of the ionosphere* [*Cambridge*] 166–71. See Abstr. 5763 (1955).

Summarizes recent experiments at the Jodrell Bank Experimental Station concerning (i) the measurement of F-region drift movements from radio star fading records taken with triangularly sited receiving equipments, (ii) the correlation of these movements with the disturbance variations in the terrestrial magnetic field, (iii) the possibility that the diffracting screen in the F-region which causes the fading is due to turbulence. A.

551.510.535 : 621.396.11

5786. Cheyenne Mountain tropospheric propagation experiments. A. P. Barsis, J. W. Herbstreit and K. O. Hornberg. *Circ. Nat. Bur. Stand., No.* 554, 39 *pp.* (1955).

Facilities for v.h.f. and u.h.f. studies include high-power continuous-wave transmitters on five frequencies, from 92 to 1 046 Mc/s. Continuously recording field-strength receivers are located at 4 fixed receiving locations ranging to 226 miles from Cheyenne Mountain, with provisions for semifixed recordings at Anthony, Kans., and Fayetteville, Ark., which are 393 and 617 miles, respectively, from the transmitter site. An extensive radio meteorological installation is located at Haswell, Colo., where accurate measurements of temperature, pressure and humidity are made with electronic measuring devices, and refractive-index turbulence is measured with the microwave refractometer developed at the Bureau. These facilities are described and sample results are reported. The new theory of tropospheric propagation embodying the Booker–Gordon scattering principles as extended by Staras is related to the measurements. A.

551.510.535

5787. Energy and duration of a sudden ionospheric disturbance. N. C. Gerson. *Geofis. pura appl.*, **27**, 156–8 (1955).

A study was made of the maximum amount of energy which might be absorbed by the atmosphere down to 80 km during a sudden ionospheric disturbance. Assuming that the ionization is caused by Lyman α radiation from the sun, and that all oxygen present is ionized, the energy absorbed by the sunlit hemisphere is $5{\cdot}65 \times 10^{27}$ ergs. A.

551.510.535 : 550.384

5788. Some geomagnetic effects in the equatorial F_2-region. N. J. Skinner and R. W. Wright. *J. atmos. terrest. Phys.*, **6**, *No.* 4, 177–88 (*April*, 1955).

The diurnal variations of the values of many ionospheric parameters obtained at Ibadan, Nigeria, close to the magnetic equator, are investigated on magnetically quiet days and on magnetically disturbed days. It is found that the midday minimum of the maximum concentration of ionization N_m in the F_2-layer disappears as the days become more disturbed. On quite days there is very little scatter of values of N_m, but on disturbed days this is much increased. Furthermore, both N_m and the total ion content, n, of a column of unit cross-section below the height of maximum ionization are greater at all times of the day on disturbed days than they are on quiet days. The perturbation of the quiet-day variation introduced on disturbed days, S_D, has not only a diurnal (twenty-four hours) component, but also a semidiurnal

component. Whilst there is general agreement in the behaviour of the results described here and the theory of ionospheric disturbances proposed by Martyn [Abstr. 7350 (1953)], the data imply that the phases of the motions differ appreciably from those suggested by Martyn. A.

551.510.535

Radio-wave propagation in the ionosphere. *See also under* "Electromagnetic waves and oscillations." Decimal classification 538.566.3

551.521

5789. Global radiation resulting from multiple scattering in a Rayleigh atmosphere. D. DEIRMENDJIAN AND Z. SEKERA. *Tellus*, **6**, *No.* 4, 382–98 (*Nov.*, 1954).

Using Chandrasekhar's solution for the radiative transfer problem in a plane-parallel model of the earth's atmosphere, under the assumption of perfect, conservative scattering according to the Rayleigh law, expressions are derived for the relative global and sky radiation received on a horizontal surface, as a function of normal optical thickness and inclination of incoming parallel radiation. The corrections representing the effect of ground reflection are also expressed in terms of certain functions already defined by Chandrasekhar. These expressions, which include the effect of all orders of scattering, are then used to compute the absolute global and sky radiation as a function of wavelength and solar zenith distance, based on the solar extraterrestrial energy curve as given recently by Nicolet. The results show that, under these assumptions, the global radiation received at the surface of the earth should remain essentially constant in spectral distribution for a wide range of solar altitudes, and that the pure sky radiation should have two maxima, centred at 3 300 and 4 100 Å respectively, for solar zenith distances ranging between 0 and 45°. The theoretical work is compared with Bernhardt's results obtained by means of certain simplifying assumptions about the successive orders of scattering. The absolute global and sky radiation is integrated over the range 0·29 to 4·00μ, and it is shown that in general the computation is in good agreement with existing measurements under clear sky conditions. A.

551.521 : 551.593.9

5790. Measurements of effective radiation at Bromma airport simultaneous with radiosoundings. O. LÖNNQVIST. *Ark. Geofys.*, **2**, *Paper* 15, 371–6 (1955).

The purpose of the investigation was to obtain a series of nocturnal radiation measurements to a cloudless sky simultaneous with radiosoundings. The need for such measurements has been stressed by many investigators of long-wave radiation, including the present author [Abstr. 3329 (1955)]. A combination of the temperature and humidity at various levels with the effective radiation makes it possible to compare procedures, such as radiation charts, presented by various investigators for the estimation of effective radiation. A.

551.557

5791. Diurnal and seasonal wind variations in the upper atmosphere. J. S. GREENHOW AND E. L. NEUFELD. *Phil. Mag.*, **46**, 549–62 (*May*, 1955).

The results of a year's survey of the winds at altitudes of 80–100 km are described. The measurements were made using radio reflections from drifting meteor trails. The principal periodic wind in this region is semi-diurnal in character, and is approximately represented by a vector of amplitude 10–40 m. sec^{-1}, rotating in a clockwise direction. The phase of the rotation undergoes a marked variation during the autumn months, but for most of the year the wind is directed towards the north near 0600 and 1800 hr local time. A small diurnal periodic wind of amplitude 5–10 m.sec^{-1}, directed towards the north at 1130 hr, has also been resolved. Prevailing winds with components of magnitude 5–25 m. sec^{-1}, towards the east in summer and winter, and towards the west in spring and autumn are observed. Components towards south of similar amplitude are present during most of the year. Turbulent winds with r.m.s. velocities of 30 m. sec^{-1}, are almost always observed. A.

551.574

5792. The heat of vaporization of a drop of solution in suspension in the atmosphere. L. DUFOUR. *Arch. Meteorol. Geophys. Bioklimatol. A*, **7**, 227–30 (1954) In French.

Aims at establishing a formula giving the heat of vaporization of a solution droplet in suspension in the atmosphere. The authors show in which cases this formula can be replaced by another one giving the heat of vaporization relative to a plane interface. A.

551.574

5793. Reversible adiabatic transformations of a drop of solution in suspension in the atmosphere. L. DUFOUR. *Arch. Meteorol. Geophys. Bioklimatol. A*, **5**, *No.* 3, 346–9 (1953) In French.

A drop of a solution is considered, which is without movement relative to the air. This system is defined and it is shown that its evolution in the course of an adiabatic reversible transformation is determined by an independent variable. An equation of this transformation is drawn up which gives the variation of the temperature of the system as a function of the atmospheric pressure. A.

551.593.55

5794. Studies of the twilight sodium lines from observations at Oslo and Tromsø, and results of auroral spectrograms from Oslo. L. VEGARD, G. KVIFTE, A. OMHOLT AND S. LARSEN. *Geofys. Publ.*, **19**, *No.* 3, 21 *pp.* (1955).

A long series of careful observations (1943–52) refute the criticisms of Bricard and Kastler (1952) by showing that the method for computing the upper altitude limit of twilight *D*-line emission, based on the time of disappearance of the emission, is valid; and is the only one available for determining the predominant distribution of atmospheric sodium atoms below this limit. The results indicate that, at Tromsø, ~34 km of the lower atmosphere is opaque to the solar radiation responsible for exciting sodium atoms below ~105 km. Moreover, the sharpness, and degree of polarization of the *D*-line emission, reported by Kastler *et al.* (1940, 1949) agree with the present results based on the Vegard method of evaluating the screening height, upper limit and thickness of the layer from which the twilight emission originates.

The seasonal variation of max. *D*-line emission, based on spectrograms obtained during 1942–49, shows a single, well-defined maximum near the winter solstice. No observations were made at Tromsø during the northern summer, June–August. D. R. BARBER

551.593.9

5795. The ultraviolet airglow spectrum. J. W. CHAMBERLAIN. *Astrophys. J.*, **121**, *No.* 1, 277–86 (*Jan.*, 1955).

A spectrum of the ultraviolet airglow has been obtained with high dispersion (23 Å/mm) and superior resolution. The rotational structure, which is clearly resolved except near the band heads, shows conclusively that most of these airglow bands arise from the forbidden Herzberg system of O_2. Longward of 3 600 Å the starlight continuum becomes noticeable and in the blue tends to obscure the O_2 emission. A few emission features remain unidentified. The relative intensities of the bands, the excitation of the upper state, the rotational temperature and the importance of de-exciting collisions in the emitting region are discussed. A.

551.593.9

5796. On a new method of determining the height of the nightglow. P. ST. AMAND, H. B. PETTIT, F. E. ROACH AND D. R. WILLIAMS. *J. atmos. terrest. Phys.*, **6**, *No.* 4, 189–97 (*April*, 1955).

A new method of determining the height by triangulation is described. A height between 80 and 100 km is indicated for the λ5577 [OI] radiation. A.

551.593.9 : 535.331

5797. Excitation of the sodium *D* lines in the nightglow. D. M. HUNTEN. Letter in *Phys. Rev.*, **97**, *No.* 4, 1178 (*Feb.* 15, 1955).

A criticism of the suggestion of Foderaro and Donahue [Abstr. 916 (1954)] that the Na–*D* radiation observed in the nightglow is transferred from the sunlit to the dark side of the earth by resonant scatter and diffuse reflection from the surface. It is pointed out that (i), the intensity-ratio of the two *D*-components, D_2/D_1, should be very large on account of multiple resonant scattering, whereas observation shows this ratio to be ~2; (ii) a thickness of 10^{11} atoms/cm^2 column is required, the observed intensity varying as a rather high power of this thickness. However, the best estimates of atmospheric Na concentration give a thickness of only 2×10^9 atoms/cm^2 column. Resonant scattering would appear, therefore, not to play a part in the mechanism of nightglow emission, although it may do so in twilight. D. R. BARBER

551.594.14 : 537.591.8

5798. Radioactive beryllium in the atmosphere and on the earth. B. PETERS. *Proc. Indian Acad. Sci. A*, **41**, *No.* 3, 67–71 (*March*, 1955).

It is estimated that about 1 000 nuclei of radioactive Be^{10} (2·7 million years half-life) are produced per m^2 per sec by cosmic-ray-induced nuclear disintegrations in the atmosphere. The conditions for observing the resulting activity in rain water and in various regions on the earth are favourable and may be useful for measuring sedimentation rates and other geological surface changes during the Tertiary. A.

551.594.21

5799. Charge generation in thunderstorms by collision of ice crystals with graupel, falling through a vertical electric field. D. MÜLLER-HILLEBRAND. *Tellus*, **6**, *No.* 4, 367–81 (*Nov.*, 1954).

When an ice-crystal impinges on the lower surface of a particle of hail or soft hail part of the charge induced by the electric field is transmitted to the ice-crystal. The relaxation time for the exchange of charge varies from a few milliseconds to about 10^{-6} seconds and is sufficiently short to enable this gain of charge. In a positive field the soft hail will therefore get a negative and the ice-crystal a positive charge. In an electric field E the final charge of a sphere with a radius R is $e_1 = -2 \cdot 12ER^2$. At temperatures between −18 and −26° the number of ice crystals is sufficient to allow a time constant of about 5 minutes for the charging process. The charge per droplet and per g. of water derived from this process are in good agreement with measurements of Ross Gunn. The growth of precipitate and the formation of strong electric fields can be brought into correspondence with the timing and development of thunderstorms. A.

551.594.221

5800. Intermittent and continuing lightning discharges in a negatively charged column. D. J. MALAN. *Ann. Géophys.*, **10**, *No.* 4, 271–81 (*Oct.–Dec.*, 1954) In French.

The mechanism is examined of lightning flashes to earth producing a pronounced final field change. A correlation is established between the magnitude of that field change and the number of component strokes in a multiple-stroke flash. Reasons are given for the conclusion that the occurrence of discrete discharges in a multiple-stroke flash and of the final continuing discharge is a function of the charge density in the vertical column along which the discharge develops [Abstr. 9856 (1951)]. It is suggested that almost all discharges to earth reach a cloud level where the temperature has fallen to −41°C and this conclusion is related to recent ideas about the mechanism of charge generation in thunderclouds [Abstr. 6182 (1954)]. R. H. GOLDE

551.594.5

5801. Theory and observations of the enhancement of auroral hydrogen lines with increasing distance from the magnetic axis point. L. VEGARD AND G. KVIFTE. *Geofys. Publ.*, **19**, *No.* 2, 10 *pp.* (1954).

Obtained with two practically identical spectrographs, one sited at Oslo, and the second at Tromsø, auroral spectra photographed during 1939–53 show conclusively that the relative intensity of Hβ at Oslo is on the average more than six times greater than that found at the higher latitude of Tromsø. This result is predicted by a modified Birkeland–Størmer theory, the enhancement of the H-intensity being due to the increasing magnetic stiffness of the solar-ray bundle towards lower geomagnetic latitudes. It is probable also that the aurorae are driven equatorward by interaction of the current system responsible for the geomagnetic storm effects; and it appears likely that the average proton velocity will increase with increasing solar corpuscular activity. D. R. BARBER

551.594.5

5802. Intensity variations of auroral hydrogen lines and the influence of the solar proton radiation on the auroral luminescence. L. VEGARD. *Geofys. Publ.*, **19**, *No.* 4, 9 *pp.* (1955).

Recent auroral spectrograms of good dispersion and resolution confirm the theoretical result that the intensity of the H-emission should increase with altitude along an auroral streamer, an effect complementary to the latitude effect (preceding abstract). A marked influence of proton excitation on the rotational energy of N_2^+ ions, and on the apparent band temperature, is found also. From low-level (~100 km) spectra where most of the luminescence is derived from electron excitation, the band-temperature coincides closely with that of the undisturbed ionosphere at the same height. On the other hand, high-level (~500 km) spectra yield band distributions which correspond to much higher apparent temperatures due to intense proton excitation. For the 0–0 band of (N_2^+1N), the observed band-temperature is ~100% higher than that of the surrounding gas.

D. R. BARBER

551.594.5

5803. A new O_2 band in the infrared auroral spectrum. J. W. CHAMBERLAIN, C. Y. FAN AND A. B. MEINEL. *Astrophys. J.*, **120**, *No.* 3, 560–2 (*Nov.*, 1954).

A strong, but heretofore undetected, auroral emission has been identified as the 1–1 band of the forbidden atmospheric system of O_2. Only transitions from $v' = 0$ have been previously observed in aurorae. The degree of excitation in the rotational and vibrational levels of the upper electronic state is discussed.

A.

551.594.5

5804. On the production of auroral arcs by incident protons. J. W. CHAMBERLAIN. *Astrophys. J.*, **120**, *No.* 3, 566–71 (*Nov.*, 1954).

A theory of the production of auroral arcs is extended to take account of a dispersion in directions for the incident protons. Earlier calculations of the Hα profile by the author [Abstr. 11675 (1954)], and the luminosity distributions (by Bates and Griffing), for the case of protons entering from only one direction, were considerably different from the observed curves. In this paper the angular distribution of incident protons is obtained by comparing the computed profile and luminosity-curves with the observational data. Essentially the same angular distribution gives a satisfactory representation of both the profile and the luminosity, which suggests that an angular dispersion may indeed be an important effect.

A.

551.594.5

5805. Variations in the auroral spectrum. C. Y. FAN AND D. H. SCHULTE. *Astrophys. J.*, **120**, *No.* 3, 563–5 (*Nov.*, 1954).

A patrol study of auroral emissions was made with a fast grating spectrograph at the Yerkes Observatory. It was found that (1) all quiet arcs showed a very intense Hα line, whereas rayed features never showed Hα; (2) the Meinel system of N_2^+ underwent little variation relative to the first positive system of N_2. The implications of these findings are discussed.

A.

551.594.5

5806. Interpretations of radio reflections from the aurora. H. G. BOOKER, C. W. GARTLEIN AND B. NICHOLS. *J. geophys. Res.*, **60**, *No.* 1, 1–22 (*March*, 1955).

Results obtained at Ithaca, N.Y., concerning radio reflections from the aurora by both pulse and continuous-wave transmissions are described. At 104 Mc/s, radar reflections show the following properties: (i) they occur only during aurorae having ray structure; (ii) the radar must be directed roughly normal to the rays; (iii) echoes are complex, indicating contributions from many scattering elements mutually interfering in more or less random phase. At various frequencies, from 2·4 to 144 Mc/s, measurements of fading show that auroral reflections fade at a rate roughly proportional to frequency; rates are between one and two powers of ten faster than would be expected for a quiet ionosphere. These observations are interpreted as indicating that radio reflections from aurorae arise by scattering from numerous auroral columns of ionization, somewhat like meteor trails, having the magnetic zenith as radiant. The fading is principally due to a wind-like motion of the auroral columns, much faster than is customary for meteor trails, and apparently much faster than can actually be observed for meteor trails occurring during auroral disturbances. Visual observations of the fine structure of rays with high-power field-glasses and by photometric analysis show that rays often consist of a large number of fine streaks, each of which extends only part of the length of the ray and lasts only about a second. It is tempting to associate these visual auroral streaks with the auroral ionization trails that are required to explain radio reflections from the aurora. Alternative interpretations suggested by other works are considered, expecially that by Harang and Landmark [Abstr. 5189 (1954)]. Reasons are given for rejecting these interpretations in favour of that described above. Although practically all of the auroral echoes observed at Ithaca are interpreted as coming from *E*-region levels, reasons are given why auroral echoes from *F*-region levels may be seen, especially by radars in lower latitudes.

A.

551.594.5

5807. Radio reflections from aurorae. II. K. BULLOUGH AND T. R. KAISER. *J. atmos. terrest. Phys.*, **6**, *No.* 4, 198–214 (*April*, 1955).

For Pt I, see Abstr. 11673 (1954). Auroral echoes recorded on a meteor survey apparatus at Jodrell Bank between June, 1949, and December, 1953, are discussed. It is inferred that the reflecting regions, in general, follow parallels of geomagnetic latitude. The diurnal variation in echo frequency exhibits a well-defined minimum between 2100 and 2200 hr U.T. and there is a complete absence of echoes between about 0600 and 1300 hr. The evening sequence (1300–2100 hr) is marked by diffuse echoes and systematic westward motions of the reflecting regions, while the echoes in the morning sequence (2200–0600 hr) have pronounced discrete structure and systematic eastward motions. The mean velocity of the reflecting regions changes from 600 m. sec^{-1}

westwards at 1500 hr to 600 m.sec^{-1} eastwards at 0500 hr and is zero at about 2100 hr (i.e. coincident with the minimum in echo frequency). A.

551.594.5

5808. The significance of a nonterrestrial magnetic field in neutral stream theories of the aurora. B. C. LANDSEER-JONES. *J. atmos. terrest. Phys.*, **6**, *No.* 4, 215–26 (*April*, 1955).

The possibility that the existence of a non-terrestrial magnetic field in a neutral stream of ions, travelling from the sun with a speed of 10^8 cm/sec, would remove a serious difficulty in the way of explaining aurorae by means of the stream when there is no such field, is examined. The analysis, which is intended to be exhaustive, leads to a process satisfactory for this purpose and needing a field in the same direction as the earth's and of a strength not less than 10^{-7} gauss, although other considerations make 10^{-5} gauss preferable. Other processes considered, requiring field strengths of at least 10^{-4} gauss, are rejected as implying great magnetic storms throughout every auroral display. It is also shown that a stream which is flowing uniformly in a magnetic field can never move out into field-free space. A.

551.596.1

5809. Theory of attenuation of sound in foggy air due to evaporation and condensation processes. Y. T. WEI. *Acta Sci. Sinica*, **2**, *No.* 4, 245–68 (*Dec.*, 1953).

After reviewing previous work on the subject, the author gives a mathematical treatment of a modified procedure. As sound waves traverse clouds or foggy air the temperature change, which accompanies the pressure variation, causes the water molecules at the surface of a drop to evaporate and those on the surrounding vapour to condense, depending on whether there is condensation or rarefaction in the sound wave respectively. In general, the pressure waves propagate ahead of the density waves since a finite time is required for this evaporation or condensation process to take place. At very high frequencies, however, the pressure varies too fast for this process to occur. Only at very low frequencies are the terms "relaxation-time," dispersion and absorption of any significance.

A. B. WOOD

TECHNIQUE. MATERIALS 62/69

PHOTOGRAPHY 77

771.36

5810. Calibration of shutter speeds. L. H. VAN DER TWEEL AND J. Q. KEYMAN. *Appl. sci. Res. B*, **4**, *No.* 4, 255–60 (1955).

A number of focal plane and central-lens shutters was tested with a specially developed simple calibrating apparatus. A.

771.5

5811. Ionic conductivity of the photographic emulsion gel. K. VACEK. Letter in *Czech. J. Phys.*, **4**, *No.* 3, 384–5 (*Sept.*, 1954) In Russian.

Samples taken from the same batch of an AgBr-emulsion gel were sensitized with equal [equivalent?] quantities of Cu, Ag and Au, ammonium rhodanides, and the conductivity was determined for each sample both in darkness and after a 140 sec illumination with a standard light source. The shape of the curve of galvanometer deviations obtained, when plotted against (1) darkness, (2) Cu, (3) Ag and (4) Au on the abscissa at equal intervals, was found to coincide almost completely with the similarly constructed curve of the total light sensitivity determined simultaneously for the individual cations (see abstract following). F. LACHMAN

771.5

5812. Chemical sensitization of photographic emulsions. K. VACEK AND L. ZACHOVAL. Letter in *Czech. J. Phys.*, **4**, *No.* 3, 385–8 (*Sept.*, 1954) In Russian.

The light sensitivity of an emulsion was determined both without and with sensitizers (double rhodanides of ammonium and Cu, Ag and Au). It was found that the variations of sensitivity were highly correlated with those of the maximum energy of the reaction $[Ag]_s + [Me^+] = [Ag^+] + [Me]$, where $[Ag]_s$ is the metallic Ag in the sensitivity centre, while Me^+ is the cation Cu, Ag or Au. In the second part of the research, the temperature dependence of sensitization with $AuNH_4(CNS)_2$ was investigated. It was found that the curves $R \ln \tau_\alpha = f(T^{-1})$, where τ_α is the time during which the maximum sensitivity (or a given fog value) is attained, are straight lines with the same slope for (1) the non-sensitized emulsion, (2) emulsion sensitized with $AuNH_4(CNS)_2$ and (3) with NH_4CNS.

F. LACHMAN